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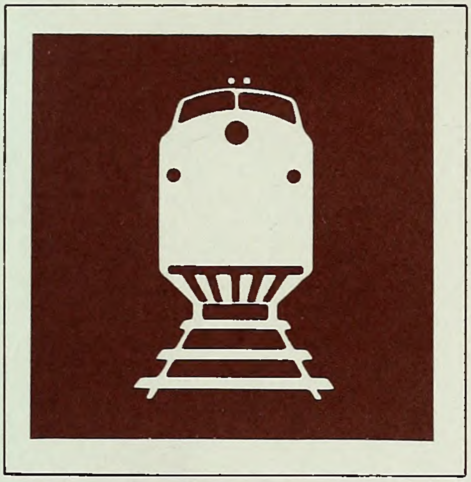

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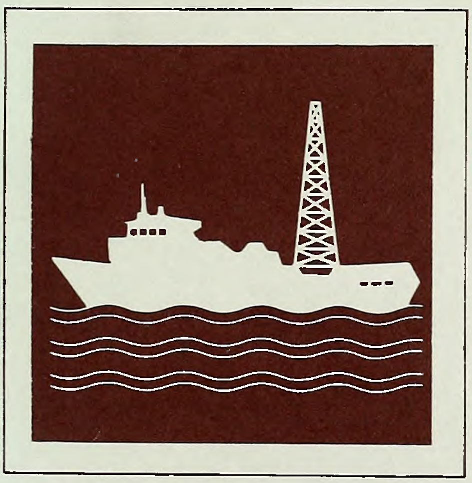

OCTOBER 1982

North Carolina
Coastal Energy Impact Program
Office of Coastal Management
North Carolina Department of Natural Resources
and Community Development

CEIP REPORT NO. 26

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Coal Train Movements
Through the City of Wilmington

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ABSTRACT

The purpose of this study is to identify and analyze the potential economic, transportation and environmental impacts to the City of Wilmington caused by the exportation of coal through the State Port. Primary attention focuses on the effects of unit train movements. Public policy actions are recommended to reduce adverse impacts.

LIST OF FIGURES AND MAPS

LIST OF TABLES

COAL TRANSPORTATION IN COASTAL NORTH CAROLINA

In 1980 and 1981 the State of North Carolina was faced with numerous proposals for large-scale facilities for shipping coal from North Carolina ports. Transportation of this coal through the coastal zone would affect many communities along the rail lines. It would also affect the terminal cities--Morehead City and Wilmington--through both rail traffic and port development. In order to prepare state and local agencies for dealing with these impacts, a major effort was organized under the sponsorship of the Coastal Energy Impact Program to discover these impacts, quantify and analyze them, and to propose mitigation measures. This present report is one of four reports which have resulted from this effort. In addition, closely related reports have been prepared on port development at Radio Island near Morehead City, alternative technologies for moving coal, and the alternative of wide-beam shallow-draft colliers for Wilmington. Those reports are listed in the list of CEIP Publications in the back of this report.

Impacts of Increased Rail Traffic on Communities in Eastern North Carolina (CEIP Report No. 17)

This study estimates the positive and negative impacts of increased rail traffic on communities in eastern North Carolina. The positive impacts include estimates of rail and port-related employment and payroll increases that could be expected if major increases in the annual volume of any bulk commodity, such as coal, were to be exported from Morehead City or Wilmington. The negative impacts focus on vehicle/train, at-grade crossing conflicts, such as traffic delay, emergency vehicle delay, accidents, fuel use, and pollution. Alternative solutions are suggested for the problems various specific communities may encounter.

A case study approach has been taken in this study, with ten local communities providing data for analysis. Seven "problem specific" solutions to increased rail traffic in these communities were analyzed: rail by-pass, grade separation, street widening, emergency services/railroad communications, fire/medical services for isolated neighborhoods, grade crossing warning devices, and city ordinances. Needs for these types of improvements in the towns of New Bern and Morehead City alone total about $90,000,000. In the other eight case study communities, needs for capital improvements to accommodate increased rail traffic total approximately $16,000,000. These needs are based on an assumed 20 million tons of export commodities annually through either of the two port cities (Morehead City or Wilmington). On the basis of these results, major commodity flows in the Wilmington rail corridor would fewer vehicle/train impacts than rail traffic in the Morehead City corridor. All other factors being equal, it is recommended that priority be given to promoting rail traffic in the Wilmington corridor.

Analysis of the Impact of Coal Trains Moving through Morehead City (CEIP Report No. 25)

This report examines the possibility of any adverse effects to the town of Morehead City and its citizens caused by the coal train transportation. Impacts are estimated for tonnages of three million and 15 million tons of coal per year. Field measurements under current conditions (coal trains at about a one million ton per year rate) were made of vibration

and traffic. Traffic delay and business effect studies were also conducted. Special attention was given to the impacts of train-caused vibrations on utility lines buried under or near the tracks.

Coal Movements through the City of Wilmington (CEIP Report No. 26)

This study identifies and analyzes the potential economic, transportation, and environmental impacts to the City of Wilmington caused by the export of coal through the State Port. Primary attention focuses on the effects of unit train movements. Special attention is given to effects on several neighborhoods which were chosen to reprent the full array of socio-economic patterns found along the rail line. Public policy actions are recommended to reduce adverse impacts.

New Bern Coal Train Study (CEIP Report No. 24)

This project, which is still underway, studies the impacts of coal trains on historic structures in New Bern. Extensive vibration studies and engineering analyses of historic buildings have been undertaken. Protective measures are expected to be recommended.

INTRODUCTION

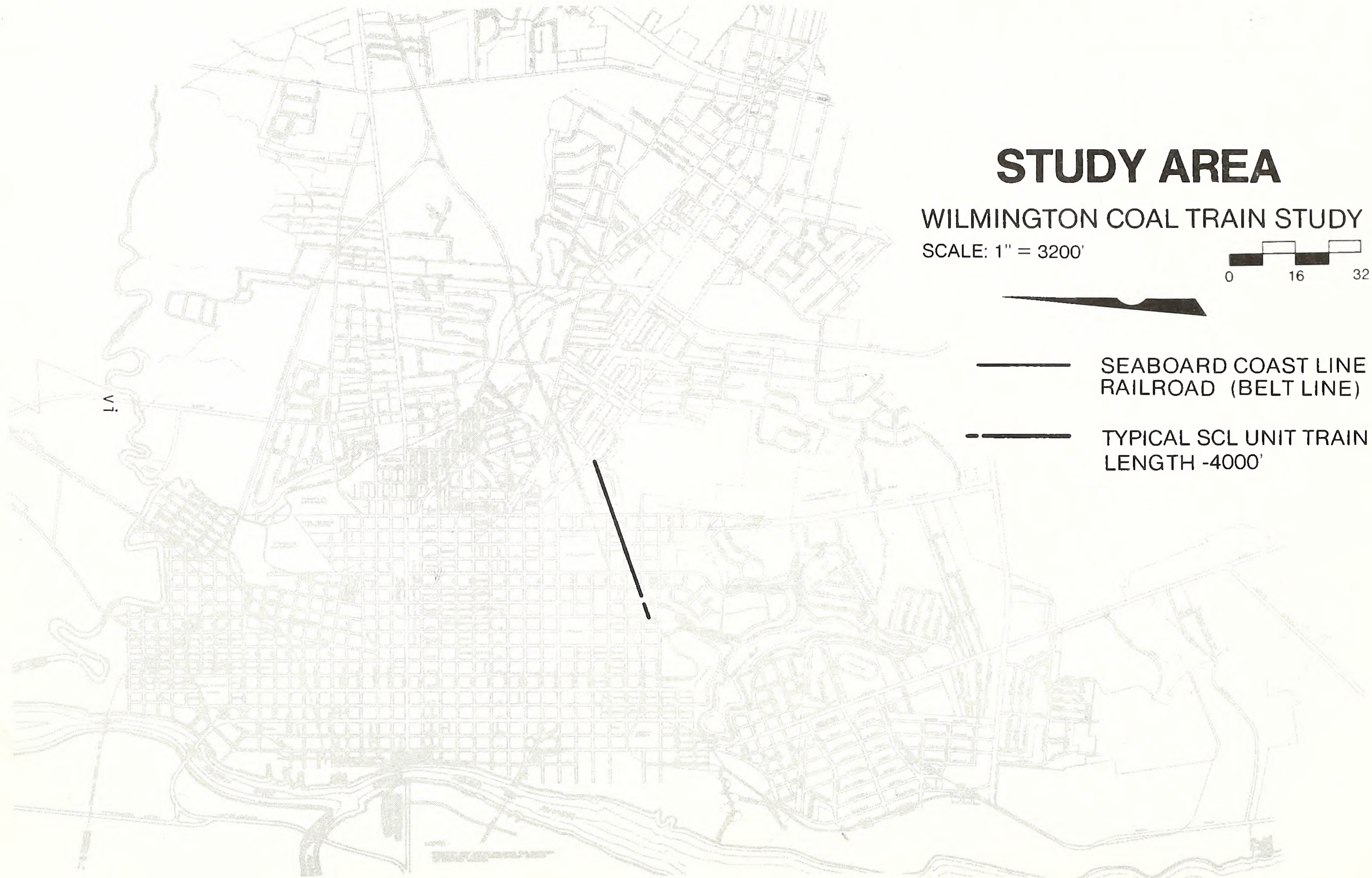
Introduction

At some point in the near future Wilmington will again be a focus of the coal export industry, as indeed was the case before the present general economic slump. There is no question that coal will be one of the most important sources of energy in the future and that, unlike oil, it will probably continue to require loading at conventional, on-shore facilities. This means that practically all ports will attract some level of coal exports.

The development of a coal export facility within Wilmington raises many questions concerning the transport of coal to a possible site at the State Port. The port is served by track owned by the Seaboard Coast Line Railroad. This track crosses at grade through the majority of the city's residential areas, commercial periphery and over major traffic arteries. Unit coal trains, approximately 4000 feet, in length would be required to supply a coal export operation.

The purpose of this study is to assess the city's potential for coal export operations and, from this, evaluate the potential economic, transportation and environmental impacts of coal transport through the city. The report focuses primarily on the State Port as a site for coal exports. The study area and related information is shown in Map 1.

A summary of major findings and policy recommendations preceeds the individual analyses of impacts. The summary is followed by Section One, which investigates the world market for U.S. coal, Wilmington's competitive position in this market and the share of coal exports that appears likely for the city. In Section Two, the economic impacts of coal exports through the city are evaluated. Section Three reports the results of an inspection of the Wilmington Belt Line. In Section Four, an analysis is made of unit train impacts on street traffic flows. The traffic study is extended in Section Five to an analysis of the probabilities of unit train conflicts with emergency vehicles at street crossings. Sections Six through Nine investigate the environmental impacts of railroad noise, vibrations, subsurface loadings and air pollution. Finally, in Section Ten a summary is provided of impacts at the neighborhood level.


STUDY AREA
WILMINGTON COAL TRAIN STUDY
SCALE: 1" = 3200'
0
16
32
SEABOARD COAST LINE
RAILROAD (BELT LINE)
TYPICAL SCL UNIT TRAIN
LENGTH -4000'

MAP 1

SUMMARY OF FINDINGS

SUMMARY OF FINDINGS AND POLICY RECOMMENDATIONS

In this section, a summary of major findings and policy recommendations is presented for each of the studies conducted in this investigation. Reference should be made to the individual analyses for detailed explanations of findings.

Section One - Coal Export Market Demand

The announcement of intentions by private industries during the past two years to develop coal exporting facilities in Wilmington and subsequent cancellations of plans raised much doubt about the growth of the U.S. coal export market. A determination of what can be considered realistic expectations of this market, and Wilmington's competitive position as an exporting site for coal, is presented in Section One. The analysis involved a review of major international studies that have been conducted by various governments on probable world market demands for coal through the turn of the century. The results of this analysis produced the following findings:

1. The current stagnation of coal market growth will not persist indefinitely. There is practically no disagreement among energy economists that coal will increasingly be used as a major energy source in all countries. The present market decline is a very temporary condition brought on by general economic recession, over-production of limited oil resources and the simultaneous application of conservation measures.

2. The increase in world demand for coal will be largely for steam coal used in power generation. By the turn of the century, this market is expected to increase by five times over current levels, to approximately 500 million short tons (2000 pounds) annually.

3. The U.S. market share will be substantial but it will face strong competition due to development of large reserves in other countries (notably South Africa and Australia) and also the expected tendency of importing countries to diversify supply sources. Given these constraints, the U.S. annual market share is forecast to rise to roughly 190 million tons.

4. The potential coal export volumes at ports in this country will follow a split between eastern and western U.S. coal reserves. The eastern market share is forecast at roughly 140 million tons.

5. When present export facility capacities are subtracted out, there remains a need for new facilities amounting to approximately 67 million tons.

6. The competition among eastern U.S. ports for a market share of the 67 million ton export deficit will be intense. Planned expansions at ports other than Wilmington account for some 85 percent of the facility needs.

7. An objective view of the competitive environment for coal exports leads to the conclusion that the probable market share of most ports has been exaggerated. This clearly seems the case in Wilmington since export facility plans for sites on the Cape Fear River would have accounted for nearly half of the available market expansion. Nonetheless, Wilmington's location, its service by Seaboard Coast Line, which is affiliated with the Family Lines network, and the availability of export sites will continue to attract investors in coal export facilities. The temporary setback of coal market growth provides a valuable opportunity for the city to evaluate the impacts of coal export trade and develop the appropriate courses of action. This study is a step in that regard.

Section Two: Public Economic Impacts of Coal Export Operations

The economic impact analysis investigated potential employment generated benefits from coal export facilities as compared to negative financial impacts on property values, traffic delays and public facilities. The employment generated benefits were based on studies conducted by the State Bureau of Economic Analysis for coal export operations at Morehead City. Interviews were also made with railroad and State Port Authority officials to determine how many new jobs would be required to service a 9,000,000 ton coal export facility at the State Port. The major findings of this analysis were as follows:

1. Approximately 70 new jobs would be created if a coal export facility were put into operation at the State Port. It is expected that most of these jobs would be filled by persons presently living in Wilmington.

2. A coal export facility would have very few links to the local economy and require no specialized services from it. Thus, it is unlikely that the facility would in any way create job opportunities other than those for its own operation.

3. The economic benefits to the service sector of the Wilmington economy would also be small. Retail sales might be

expected to rise by roughly $600,000 per year from purchases made by job holders at a coal export facility. This amount would return roughly $6,000 to the city's tax base.

4. On the negative side, the increased train movements that would be needed to serve a coal export facility will create substantial costs. Property values may decline by approximately $1,045,000 due to noise and vibration effects. Increased vehicle delays could add $679,800 to $1,095,000 annually to the cost figures. Also, it is expected that reconstruction of various underground utilities would be needed to support train loads. The latter two cost figures are explained in other parts of this summary.

Section Three: Belt Line Track Inspection

The Wilmington Belt Line, which is owned by Seaboard Coast Line Railroad, was inspected to determine its general condition and suitability for unit train operations. This inspection was conducted according to Federal Railroad Administration standards for Class I track. This is the designated class of the Belt Line and implies a maximum permissible operating train speed of 10 miles per hour. In addition to a general finding that the track will need extensive upgrading to handle unit coal trains, a number of serious problems were found that should be given immediate attention. The results of these findings are listed below:

1. The crossties of the Belt Line are generally in poor condition throughout its length. At least 75 cases were noted in the inspection that indicated tie defects. These defects can cause the track to deflect, spread, or break under the weight of a train, possibly leading to derailment.

2. The sections of the track which seem to contain the most prevalent tie problems are found from Covil Avenue to Market Street and 30th Street to King Street. Nearly all track sections, however, need extensive tie replacements, probably as many as 700-800 ties per mile.

3. Four gage defects (i.e., the permissible space between left and right tracks) were noted at 5th and Martin Streets, between 5th and 6th Streets, at the point of the track curve between Covil Avenue and Market Street and near the McRae Street overpass. These defects are very serious derailment hazards.

4. In many of the sections of the track, the joint bars (the devices that bolt together sections of track) were found to be loose. There are also numerous quarter breaks in these bars.

5. Except for a short track section in the area of the old Atlantic Coast Line switching yard, there is no rail on the Belt Line which can support the impact of unit coal trains.

The inspection simply confirms the very marginal use the Belt Line track presently has. Extensive track upgrading would be required before any unit trains could be put on regular schedules. Furthermore, even for existing trains, the track needs immediate repairs to allow safe movements.

Policy Recommendation: The city should encourage the Seaboard Coast Line to upgrade the Belt Line in its entire length, whether or not coal transport develops. The findings of this study should be brought to the attention of Seaboard officials.

Section Four: Unit Train Impacts on Street Traffic Flows

A comprehensive analysis was undertaken to determine the traffic impacts that would be caused by increased train movements over the Belt Line. This analysis involved a computer simulation of city traffic flows based on traffic counts conducted by the Wilmington Planning Department. Sixteen critical railroad and street intersections plus major feeder streets were investigated in detail against three conditions of train operations. These scenarios took into account what is considered to be practical variations in train speeds, train lengths and operating frequencies to transport 9,000,000 tons of coal annually. Based on the computer simulations, figures were derived to show total daily hours of vehicle delays and from these, an estimate was made of public costs due to increased driving times for motorists. The major findings of the analysis were as follows:

1. If unit trains are placed on the Belt Line, 453.20 to 730.00 delay hours will be added daily to existing traffic flow conditions, depending on train speeds, lengths and frequencies tested in the operating scenarios.

2. The intersections of Market and 30th Streets and 16th and Dawson Streets, which are traffic bottlenecks under existing conditions, will be severely affected by unit train movements.

3. If it is assumed that the value of time while driving is at least $6.00 per hour to drivers and passengers, the public costs due to increased traffic delays from train movements will range annually from $679,800 to $1,095,000. Additional expenses can also be assumed due to increased periods of engine idling, starting and stopping and related operations. These costs may range from approximately $84,839 to $136,656.

4. The higher ranges of potential public costs will result if unit trains are operated at 10 mile per hour averages. An increase to 20 miles per hour average speeds for the trains on the Belt Line will reduce traffic delays from train movements by approximately 40 per cent.

The results of the traffic simulations indicate a substantial yearly cost in vehicle delays to the public if unit train movements are made over the Belt Line. The speed of the trains is critical to minimizing delays in the traffic network.

Policy Recommendations: If unit trains are placed in service, the city should encourage the Seaboard Coast Line to make improvements necessary to increase operating speeds to 20 miles per hour. Any increment over 10 miles per hour should not be overlooked in importance to reducing street traffic delays. The city also should work with the railroad toward avoiding train movements during street rush hours.

Section Five: Emergency Vehicle Impacts

Section Five contains an analysis of potential conflicts between fire and rescue squad emergency vehicles and unit train operations. A probability model was used to evaluate the likelihood of conflicts. This model required a historical trend analysis of fire and rescue squad calls, destinations and total response times by service zones. Historical records were prepared by the Wilmington Fire Department. Detailed probabilities for conflicts and expected delay times for each service zone are presented in the texts. The general findings were as follows:

1. Due to geographic locations of fire stations in zones serving the neighborhoods of Sunset Park, South Wilmington, East Greenfield and the University area, Fire Department vehicles do not have to cross Belt Line tracks and thus, conflicts are not an issue.

2. For the remaining fire service zones in the city which require Belt Line crossings, the probability of a conflict with a unit train (assuming 10 one-way train movements) will range from .0008 to .010 per call (i.e., approximately 1 to 10 times per thousand calls).

3. When a fire vehicle and train conflict does occur at a Belt Line crossing, given the chances of such an occurrence, the delay per conflict will average 136 seconds. When averaged over all yearly responses, this delay will be .23 to 2.81 seconds per response.

4. One neighborhood area, Love Grove, should be of concern for both fire and rescue squad service since the Belt Line crosses the single street that provides access to the neighborhood. If a derailment were to occur at this crossing, the neighborhood could be isolated completely for some period of time from emergency vehicles.

5. For the rescue squad vehicles, conflicts with train movements could be expected to be higher since calls typically require trips to the accident as well as to a hospital. For Zone 1, which serves the western and downtown areas of the city, conflict probabilities were estimated to be .0179 to .116 per trip (roughly 18 to 116 conflicts per 1000 trips). When a conflict occurs, the average delay for a rescue vehicle will be 136 seconds and, in unusual cases could be twice this amount (272 seconds) if a train is encountered both on the trip to the accident and on the return to a hospital. When averaged over all expected yearly trips, the average delay for any response will range from 4.87 to 31.77 seconds. The upper range indicates a serious delay time although, as noted in the detailed analysis, the chances are small for this amount of delay.

6. For Zone 2, which serves the eastern part of the city, the conflict probabilities were found to range from .0017 to .029 per trip (i.e., approximately 2 to 29 conflicts per 1000 trips). The average delay time for an actual conflict between a rescue squad vehicle and a train is the same as in Zone 1 (i.e., 136 to 272 seconds). However, due to differences in rescue squad locations, the expected delay in Zone 2 for any response, averaged over all calls, will be much lower, ranging from .48 to 4.14 seconds.

7. The rescue back-up service provided by Empie station to Section 1 of Zone 1 (the Brooklyn area) has to cross the Belt Line twice on the response trip and twice again if a return is made to a hospital. This is the only service that has a large delay factor (delays could average 31 seconds per response) but the probabilities of the delays occurring are small.

As a general finding, the emergency vehicle conflicts posed by unit train operations are low relative to many other possible delays that may block the timely arrival of these vehicles. Nonetheless, even small increments of time are critically important in fire and rescue operations, and unit train movements will add in some measure to delay times.

Policy Recommendations: No changes in response in fire or rescue service patterns would appear necessary for unit train movements at the levels discussed with the possible exception of Empie station back-up service to the Brooklyn area. The city should investigate a back-up service that minimizes Belt Line crosses for this service area. An alternative entry should be developed into the Love Grove neighborhood in case of derailments.

Section Six: Railroad Noise Impacts

An analysis was made in section six of the effects unit trains would have on existing noise levels in areas adjacent to the Belt Line. The analysis provides noise level data for single train movements and for average total effects over a 24-hour day. The findings were as follows:

1. Disturbing noise levels could be expected to extend to approximately 1,000 feet from either side of the Belt Line.

2. Within the 2,000 foot corridor, noise levels from four additional round trip movements will change community noise levels significantly. On a 24-hour day, perceived noise levels will be approximately double those of existing conditions.

3. The train noise would not be expected to have detectable effects on the physical health of residents living along the Belt Line, but hearing and communication will be disrupted during train movements.

4. Changes in the level of community noise may be expected to have adverse effects on property values. An estimated loss value of $1,045,137 could occur as a result of increased noises (this figure is derived in section two on Economic Impacts).

5. Train movements can be expected to cause disruption in hearing and speech communication in schools located near the Belt Line. Comprehension during lectures or other classroom work would be a particular problem for children with learning disabilities.

The significant increases in noise are a normal function of train operations and there is little the city can do on a public level to reduce noise impacts. Private property can be retrofitted by owners with various sound absorption materials, such as door and window gaskets. These types of improvements are highly effective in reducing exterior noise but are not inexpensive. A noise control ordinance for train movements would not be enforceable. The Federal Noise Control Act controls standards for locomotive noises.

Policy Recommendation: The city should encourage the railroad to maintain track so as to minimize noise from train movements. A noise control ordinance is not recommended because of lack of enforcement authority at the local level. The county should retrofit school doors and windows with gaskets to retard noise intrusion from train movements if unit trains are placed in service.

Section Seven: General Vibration Impacts

An analysis was made in Section Seven to determine the effects of unit train induced vibrations in areas of the city next to the Belt Line. Vibrations from train movements are represented primarily by surface waves which leave the track area much like the movement of water waves across the surface of a pond. Humans cannot feel vibrations produced by a passing train unless they are standing next to the track. These waves, however, will cause perceptible movements in houses or other building structures. The analysis in Section Seven produced the following findings:

1. Significant vibration waves from passing trains can be expected to largely dissipate at 600 feet from the Belt Line track. It is estimated that 3,121 residents are located within this distance.

2. Perceptible movements from vibration wave action on houses and other buildings will occur within the 600 foot distance from the Belt Line. Structural damage to buildings is not considered likely although it is possible that hairline cracks in old plaster or similar materials could occur over time.

3. Residents within the 600 foot distance will sense vibrations as rumbling sounds due to building movements. These sounds may be highly annoying in some buildings and will vary according to building construction characteristics.

4. The intensity of the sounds caused by vibrations will decrease by approximately 6 dB per doubling of distance from the track. The most annoying sound levels would be within the first 400 foot distance from the Belt Line. At this point, vibration waves will produce decibel levels ranging from 61 dB to 85 dB, which is roughly twice the present sound level for Belt Line neighborhoods.

As a practical matter, there is no inexpensive physical improvement that can effectively reduce expected vibrations on existing structures. These impacts must simply be viewed as a public cost of Belt Line service.

Policy Recommendation: No policy action other than encouraging the railroad's proper maintenance of the track is recommended.

Section Eight: Vibration and Loading Impacts on Underground Utilities

The Belt Line track is crossed underground by numerous utilities in the city's water, sewerage and storm drainage systems. The analysis in Section Eight investigated whether or not the increased loads and subsurface vibrations of unit coal trains pose possible structural damages to these utilities. Eighty-one utilities were identified by the city's Public Works Department. Of this number, 52 were selected for more detailed investigation based on preliminary indication of possible structural problems. It was necessary to make a number of assumptions concerning the installation methods for the buried pipe. The results of the analysis are summarized below:

1. It was found that twenty-six utilities may have loading problems from unit trains that significantly exceed allowable standards. These include fourteen sewer mains, ten storm drainage mains and one water main.

2. The exceeding of the allowable loads can be expected to cause the development of significant structural cracks and may result in complete pipe failures.

3. If further analysis confirms the suspected overloads, it is likely that the pipes will have to be replaced. It is roughly estimated that a conservative replacement cost would be at least $315,000, excluding engineering, project administration and various other costs.

The results of the analysis in Section Eight indicate that unit train loads should be of serious concern. It is recommended that a detailed structural analysis be undertaken to determine precisely the extent of loading problems.

Policy Recommendation: The city should conduct detailed site investigations of utilities identified as having potential loading problems for unit train service. If the problems are confirmed and the railroad places unit trains in service, the city should pursue a cost recovery from the railroad.

Section Nine: Unit Train Air Pollution Impacts

The potential impacts of coal dust particulates and engine exhaust emissions from unit coal trains were investigated in Section 9. The analysis reported research conducted by the Department of Energy for dust loss. A plume model was used to determine "worst" case emission levels. These levels were then evaluated in terms of coal transport distance to Wilmington, train

speeds on the Belt Line and the effects of local climate conditions. The findings were as follows:

1. Under "worst" case conditions, the transported coal will have a dust loss factor of approximately .25 percent of coal transported. Given annual transports of nine million tons for a State Port facility, with four daily unit train movements, it can be estimated that as much as one pound of dust per mile could be emitted daily from train movements over the Belt Line. This rate of emission is below particulate maximums allowed under Environmental Protection Agency standards.

2. Several significant mitigating factors indicate that in actual operating conditions, coal dust loss in Wilmington from passing trains will be far less than suggested in item 1 above. This reduction is due to: 1) an assumption that most coal dust will blow out during early stages of the trip from the mine; 2) the unit trains will travel at slow speeds on the Belt Line; and 3) regional climate conditions are favorable to minimizing emissions.

3. The number and time intervals between unit train operations on the Belt Line indicates that federal air quality standards will not be exceeded in Wilmington.

As indicated in the findings above, the coal dust and engine exhaust emissions from unit trains on the Belt Line would not be expected to be a serious concern. It is expected that dust concentrations from any single passing train will not be detectable. At this level of air pollution, methods for further reduction are not practical.

<u>Policy Recommendation</u>: No policy actions are recommended at the levels of projected unit coal train movements.

Section Ten: Neighborhood Impacts

The final section of the report provided a quantitative summary of those neighborhood populations that will be directly affected by unit train noise, vibrations and property depreciations. The estimates of population were made using 1980 Census block statistics developed by the Planning Department. The total neighborhood populations affected by unit train impacts were found to be as follows:

Persons living in 1,000 foot, 60 dBA noise corridor: 6,273

Persons living in 600 foot vibration corridor: 3,121

Persons affected by dust pollution: No Measurable Effect

Housing units in 1,000 foot noise/vibration corridor: 2,579

COAL EXPORT MARKET

COAL EXPORT MARKET DEMAND

The recent behavior of the international coal market -- its steep rise followed by collapse -- points to the problem of making predictions on future demands of export products. During the past two years, six firms announced plans to develop coal shipping facilities along the Cape Fear River; most have canceled the plans or at best are much more uncertain about following through on investments.

In the long run, there seems to be no disagreement that the demand for coal will grow far in excess of any other energy commodity. The problem for investors in today's market of tight money and extremely high interest rates is that the timing of investments leaves little margin in which to work. Thus, Wilmington and other port cities, which are served by coal hauling railroads or barge lines, became the focus of a great deal of investment activity two years ago when it appeared that declining but steeply priced oil supplies would break open the coal market. In fact, combinations of economic recession in Europe, energy conservation measures, and over-production of present oil supplies, have put strong restraints on the growth of the coal market at the present time.

For Wilmington the questions of when and how the coal market will develop are important because coal trade has long-term implications on such matters as land use, rail and highway conflicts, the local economy and the nature of channel traffic and development. This section will present a broad overview of major elements that are shaping the coal market, including: (1) the developing demand for coal; (2) factors influencing the U.S. share of the market; and (3) the competitive position of Wilmington in this market and potential tonnage projections relative to coal transport movements through the city.

World Coal Demand

During the last five years there have been a number of comprehensive studies of the international coal market, as for example, the reports by the U.S. Department of Energy, Interagency Coal Export Task Force, the International Energy Agency study on the European steam coal market, and the World Coal Study (WOCOL). These and similar studies have been in agreement that the world demand for coal will increase several times over the present market by the turn of the century.

In the past, the U.S. Market was dominated primarily by metallurgical coals used in making iron and steel. While this market will continue modest growth, it is expected that it will be overshadowed by a vastly increased demand for steam coal. The various export facility plans that have been proposed for Wilmington are designed for the steam coal market. This type of coal is used primarily in the electric utility industry. The market has been stalled temporarily, however, by excess oil production and world industrial stagnation. Neither of these conditions are expected to persist. Oil reserves are limited and, even in a glutted market, the prices per BTU exceed those of coal. Further, the electric utility industry will continue to convert existing oil fired plants to coal, though the timing of these conversions is influenced by government policy as well as energy economics.

As time passes, it can be expected that cost and production factors in petroleum supplies will create conditions that are increasingly favorable to a widespread conversion to coal use. By the late 1990's, according to the various international studies cited above, it can be projected that steam coal demand may rise by as much as five times over its present 100 million ton market.

Factors Influencing the U.S. Market Share

Despite the anticipated growth of both the steam and metallurgical coal markets, there is a great deal of uncertainty about how much of this market the U.S. will capture. A number of factors are contributing to this uncertainty, as explained below.

First, U.S. coal will have to compete against other suppliers, notably South Africa and Australia, which together have the capacity to supply the entire world steam coal market into the next century. It appears that the price per ton of coal supplied by these countries can undercut the U.S. price by $5-15 per ton, (in 1982 dollars) depending on destination. The price advantage in both countries is due primarily to lower inland transportation costs.

A factor that should mitigate to some extent the price advantage of South African and Australian coal is that these and other supplying nations may be willing to let U.S. coal capture a large share of the market in order that U.S. prices can set the standard for international coal trade. Still, the price disadvantage and the abundance of coal in South Africa and Austrialia means that the U.S. cannot control the market.

The reliability of the U.S. market to supply other nations consistently with needed quantities of coal is an issue that is also foremost in figuring market share. Rail strikes, mine strikes, dock worker strikes, the harbor facilities themselves and demurrage costs, are all factors that the international buyer must try to account for in establishing long-term relationships. Of course, other supplying nations have similar disruptive supply factors. The strategy that coal importing countries are likely to follow to reduce the threat of disruptions in the supply line is to spread their buying over a large number of supplying countries. The lesson of dealing with single suppliers in oil who could easily shut down production has not been lost on European or other buyers and reinforces the strategy of diversification. The result of this strategy will assure the U.S. a strong market but not domination of that market.

Finally, a very uncertain element in determining U.S. share is the role of technology. Under this heading may be lumped the diverse issues relating to such factors as shipping size, channel depths, loading facilities, rail hauling, off-shore technology, and the development of liquid or hybrid coal fuels which will require liquid handling facilities, such as the slurry pipeline concept. Major break-throughs in the use of these technologies, which are as much problems of legislation as engineering design, could dramatically change the U.S. position in the market.

Taken as a whole, the previously cited international studies that have looked in detail at coal market forces indicate a world steam coal market by the turn of the century of some 500 million tons, and a U.S. share of the market ranging from 25-50 percent for the European market and 10-25 percent for the Pacific Rim market. It is further projected by these studies that European and Pacific Rim coal use will be roughly equivalent. These assumptions indicate that the market share for the U.S. should fall between about 90 million tons on the low side to some 190 million tons on the high side. The higher figure will be used as a basis for analysis in this report.

U.S. Coal Market Split and Export Facility Needs

The need and/or investment attractiveness of coal export facilities in Wilmington and the Cape Fear area can be considered a subset of the international factors that affect the U.S. market share. In addition, there are State and local factors that directly affect Wilmington's potential market share of U.S. coal exports. These are discussed below.

It must be considered first that Wilmington's location on the eastern seaboard strongly directs its potential export market to

Europe. (Although Japan ships large tonnages out of eastern ports, primarily Hampton Roads, this has been out of necessity for its metallurgical coal needs. Future Japanese steam coal demand from U.S. sources will probably be satisfied by western U.S. coal reserves). The share of the U.S. market that Wilmington may capture will be only that part concerned with European demands (or similar Atlantic countries).

The Interagency Coal Export Task Force assumes that roughly 74 percent of the split (or 140 million tons) of the anticipated 190 million ton steam coal market will be taken by eastern coal exports. This figure can be considered the annual upper limit coal tonnage that will be shipped through eastern U.S. ports toward the end of the century. As pointed out earlier, various intervening market forces could reduce this figure substantially.

The 140 million ton projected eastern export market total can be viewed as a "pie" from which some slices have already been taken by ports with existing coal facilities (or facilities under expansion). The remaining portions are potentially available to Wilmington or other ports that have not previously exported coal.

Figure 1 shows the existing and potential effective capacities for eastern ports. Effective capacity refers to the operating capacity of the port that can be sustained over long periods of time rather than the absolute amount of tonnage that can be accommodated under special circumstances. As indicated by the totals of effective capacities (113.8 million tons), plus expansions underway (18 million tons), U.S. eastern ports without further development are able to handle nearly 132 million tons of coal, of which some 59 million is metallurgical coal. Thus, present steam coal effective capacity at eastern ports is 73 million tons, leaving an expansion need of 67 million tons if the 140 million ton future U.S. market is to be accommodated by the turn of the century.

As indicated in Figure 1, efforts to remove under-capacity have already gone through at least the planning stages for ports shown. In fact, if all the planned expansions shown in Figure 1 were carried out, there would be 57 million tons of effective capacity added at eastern U.S. ports (118 million tons absolute capacity).

The figures above indicate some measure of the competitive nature of the projected coal export market within the U.S. The market is large, at least from the standpoint of bulk tonnage, but it is not so large that eastern ports will have more coal exports than they can handle.

It is also instructive to note that Wilmington is not listed in the ports shown. However, if the facilities announced for the

(millions of short tons)

Port/Terminal	Vessel Size (DWT)		Existing Capacity (10^6 tons)		Capacity Expansion (10^6 tons)		Total Mid to Long-Term* Effective Capacity, 1985 (10^6 tons)
	Existing	Proposed	Designed	Effective	Planned	Underway	
East Coast							
New York, New York (P)	80,000				5.0		5.0
Philadelphia-Pier 124 (E)	60,000		5.0	2.5		6.5	9.0
Camden, New Jersey (P)	35,000				2.0		2.0
Wilmington, Delaware (P)	30,000				7.5		7.5
Lower Delaware Bay (P)	100,000+				10.0		10.0
Baltimore (E)	70,000	100,000+	27.2	16.6	11.0	6.5	34.1
Norfolk-Pier-6-North (E)	80,000	100,000+	58.0	29.0	7.3		36.3
Pier-5-South (E)			8.0	4.0	1.0		5.0
Newport News-Pier 14 (E)	80,000	100,000+	33.0	16.5			16.5
Pier 15 (E)			14.6	5.3		5.0	10.3
Pier 9 (E)					5.0		5.0
Portsmouth (P)	50,000	100,000+			10.0		10.0
Morehead City (P)	50,000	100,000+			5.0		5.0
Charleston (P)	40,000	50,000			5.0		5.0
Savannah (P)	50,000	70,000			7.5		7.5
Brunswick (P)	30,000	43,000			5.0		5.0
Total East Coast			145.8	73.9	81.3	18.0	173.2
Gulf Coast							
Mobile (E)	60,000	100,000+	11.0	5.5		5.0	10.5
New Orleans-Davant (E)	60,000	100,000+	14.0	7.0	3.0		10.0
Myrtle Grove (E)	60,000	100,000+	6.0	3.0	9.0		12.0
Mile 119 (P)	60,000	100,000+			4.0		4.0
Baton Rouge (Burnside) (E)	60,000	100,000+	5.0	2.0	4.0		6.0
Port Arthur (P)	60,000	100,000+			2.0		2.0
Galveston (P)	55,000	100,000+			10.0		10.0
Corpus Christi (P)	75,000	100,000+			0.5		0.5
Total Gulf Coast			36.0	17.5	32.5	5.0	55.0

(E) Existing Facility
(P) Potential Facility

Source: Maritime Administration. The columns showing capacity expansion and effective capacity are not dependent upon the deepening of channels at the respective ports; however, the column showing proposed vessel size is dependent upon the completion of dredging projects.

* Based on survey of U.S. ports, using 1985 as nominal date for mid- to long term coal port development plans.

Figure 1. Existing and Potential Effective Capacity for Handling Export Coal at U.S. Ports

Wilmington area had been built as planned, they would have had a total effective capacity ranging from 25 to 37 million tons annually. This total would account for nearly half of the entire capacity that eastern ports will need to develop by the turn of the century. Considering the many factors that are shaping the future coal market, it is unlikely that Wilmington or any single port will capture that much of the future market. What is happening generally, and may be presumed for coal export development in Wilmington, is that investors are speculating on the coal market in a very uncertain and uncoordinated environment. In anticipation of a coal market upswing they have been "testing the water"-- taking options on export sites; developing plans; in most cases, drawing back. The process has raised a lot of issues prematurely in U.S. ports but it is likely to continue until the future growth of the coal market is better defined.

Projected Wilmington Coal Export Potential

As suggested above, the real potential coal export market for Wilmington between now and the turn of the century is probably far less than indicated by promoters of export facilities during the past several years. Determining that market involves a great deal of uncertainty, since for any particular port international market forces are beyond any practical manipulation and, even in the case of the country as a whole, are not, for reasons cited earlier, subject to the types of business forecasts associated with products for purely domestic consumption. With this uncertainty in mind, there remain some factors that help define the City's potential as a location for coal exports, as explained below.

First, the Seaboard Coast Line, which provides all rail service to Wilmington, is affiliated with the Family Line System, a major coal carrier. The Family Line System provides service to about 60 percent of the available central Appalachian coal reserves. As a general rule of thumb, the rail service percentage has traditionally been closely related to the share of coal export trade that can be captured by a railroad. This share, in turn, filters down to the various ports in which the railroad has facilities, as in Wilmington.

A second factor that influences venture interest in Wilmington is the availability of coal export sites. The western side of the Cape Fear River is virtually undeveloped, although constrained by environmental factors at many locations. The east side of the Cape Fear River has few remaining sites but among these is the State Port (see map 1) which has substantial investments in shipping facilities and could be adapted for coal export trade. At the present time, potential storage and loading facilities are organized primarily for container trade and related internal traffic patterns and by wood pulp shipping operations.

The wood pulp operations have recently been added and occupy a 15 acre site for which a coal export company announced preliminary development plans in 1981, prior to later dropping negotiations with the Port Authority on the site. The potential future development of the State Port for coal exports would require either substantial rearrangements of existing container trade operations or the vacating of other presently occupied sites. While there are 60 undeveloped acres at the northern end of the Port Authority land, this site is underlain by peat material and would require costly infilling to support coal unloading and storage for shipping.

A second potential coal export site within Wilmington on the east side of the Cape Fear River is located near the downtown district on Nutt Street (see map 1). This site is served by a rail spur to the Wilmington Belt Line and was recently proposed for coal export operations of approximately three million tons per year. District zoning regulations do not permit coal operations at this location.

Given the direct rail link to central Appalachian coal fields, and potential coal export sites in the city, a third factor which defines market potential is the adequacy of channel depth in the Cape Fear River for coal colliers. The Cape Fear River has a 38-foot draft which is the minimum necessary for accommodating smaller coal colliers (50,000 dead weight tons or less) now being used in international trade. Geologic studies conducted by the Corps of Engineers in Wilmington have established that further deepening of the present channel is not feasible due to bedrock strata and consequent excavation expense.

The long-term future for the use of the smaller colliers will be determined by presently unresolved questions concerned with shipping efficiencies and the channel accommodations made at receiving ports in other countries. Although there has been increasing interest in the shipping industry toward the use of larger colliers ranging up to 400,000 dead weight tons (DWT), the substantial financial costs, environmental constraints, time involved to improve channel depths at virtually all major international ports and the unsuitability of the Panama Canal and Suez Canal to accommodate the larger colliers, indicates the continuation of a significant market for smaller colliers into the next century. Thus, despite the 38-foot channel limitation, Wilmington will likely continue to attract the interest of smaller coal export shippers.

Site and Tonnage Capacity

The State Port is the only facility within Wilmington proper that will have direct environmental impacts on the city and is not

constrained by local restrictions against development. The zoning restrictions on the Nutt Street site are assumed to be long-term; however, as the growth in the coal market picks up momentum, there will obviously be developer interest in this site for coal exports. For this reason, some limited attention is given to the Nutt Street site in various analyses presented in this report.

Previous studies conducted by the State Coastal Management Program estimated coal storage and loading capacities at the State Port to have a range of 4-9 million tons. Site visits conducted during this research generally confirmed the upper limit of this range unless costly improvements are made to develop the 60 acre site at the Port which was identified above as having severe environmental constraints for the storage of coal.

The development of a 9 million ton facility would require a substantial increase in train operations on the Belt Line track operated by the Seaboard Coast Line Railroad. Officials of the railroad have indicated that their operations would involve the use of 70 car unit trains having a hauling capacity of 100 tons per car (or 7,000 tons per train). Four diesel engines would be required for power. The trains would be operated seven days per week, averaging four trains per day (eight one way trips). The trains would enter the Wilmington Port from the Navassa Switching Yard on the west side of the Cape Fear River, thus moving through the city on the entire length of the Belt Line.

The potential Nutt Street terminal would average a single unit train daily (two one-way trips) with approximately the same number of cars. Annual exports from the facility could range as high as 3 million tons. Trains entering this terminal would come in on a spur track leading from the Belt Line near the Hilton Bridge (see Map 1). This track is not a major factor in automobile traffic conflicts but would cause noise and vibration impacts.

Although this report will focus on the State Port and downtown terminal impacts, it should be emphasized that the market for these facilities can be satisfied by a number of other locations on the Cape Fear or Brunswick Rivers. By the same token, if the downtown terminal and State Port are developed for coal exports, these facilities may largely capture the potential coal export market for the city.

COAL EXPORT ECONOMIC IMPACT

Public Economic Impacts of Coal Export Operations

This section investigates public economic impacts that can be expected to result from the development of coal exporting facilities at the State Port. The major findings of this section indicate that benefits would likely be marginal to the city, with relatively the same impact in New Hanover County. Financial benefits to the State will be substantially greater.

Methods of Analysis

The determination of benefits for a nine-million ton coal export facility at the State Port is based primarily on an analysis of employment that the facility will create, including a multiplying effect on service jobs within the city's economy. An estimate of potential jobs needed to operate a nine-million ton facility was developed through interviews with coal industry economists and State Port officials. Railroad employment estimates were provided by the Seaboard Coast Line Railroad. The job multiplying effect (i.e., secondary jobs generated) was derived from estimates supplied by the State Bureau of Economic Analysis for similar coal exporting operations in Morehead City. Other benefits and negative impacts were developed from investigations made for the impact analyses in this report.

Employment Impacts

Projected population and employment impacts that may be generated by annual coal exports of nine-million tons at the State Port are shown in Table 1. Figures for the previously proposed Nutt Street terminal site have not been entered into benefit estimates because of recently enacted zoning restrictions at this site.

As shown in Table 1, an estimated 70 port and railroad jobs would be created by development of a coal exporting facility at the State Port. These jobs, in turn, could possibly generate as many jobs again in the SMSA for support services. Based on the State Bureau of Economic Analysis figures, Wilmington could capture one-half the total employment impact and associated economic benefits.

As a practical matter, there are a number of factors that suggest that the employment benefits in Table 1 are optimistic, particularly in respect to the population increase. For example, unlike a highly specialized industry, it is very unlikely that a coal storage and handling facility will require skills that are not available in the Wilmington labor force. It can also be

Table 1. Employment and Population Impacts for 9,000,000 Annual Export Tons

Description	Rate
Tons shipped per year	9,000,000
Tons shipped per day (360 days/year)	25,000
Tons per Train (100 tons/car; 70 cars/train)	7,000
Trains per day	4
Required increase in RR employment	20-30
Increased RR employment in 5-day week equivalent	30
Increased employment in port in 5-day week equivalent	40
Total direct employment, 5-day week equivalent	70
SMSA multiplier	2.0
Total increase in SMSA labor force	140
Share of labor force increase in Wilmington	70
Labor force participation rate	.45
Increase in Wilmington population	155
Increase in households in Wilmington	55

expected that there is probably enough slack in the local economy to allow local residents, rather than outsiders, to take most of these jobs.

The multiplying effect is also likely to be overstating job creations since coal loading operations have few links to the Wilmington's economy and will make few demands on it. The coal will be mined in other states and will not be processed in any way in Wilmington. Its handling does not appear to require either locally produced goods or services.

Some question may also be raised as to whether the assumed split between Wilmington and the rest of the county regarding potential population increases does not also exaggerate the city's potential share. Although annual housing starts in the city account for approximately one-half of the combined city and county total, the city's proportion has, as in most metropolitan areas, been declining relative to the County and the SMSA.

Based on the reasons cited, the employment benefits and related job and population multiplying effects are not expected to be as significant for a coal loading facility as might be expected for a more specialized industry that uses local resources. Nonetheless, even if the figures in Table 1 are accepted as presented, economic benefits for a nine-million ton level of exports will be nearly undetectable in the city's total economy. For example, the estimated population increase would be three tenths of one percent of the City's present population. The increase in employment relative to total employment in Wilmington would fall in the same range.

Although increased employment will generate some direct effects on retail sales, these effects will again be relatively insignificant. Retail sales in Wilmington, as measured by the 1977 census of retailing, were approximately $275 million. A conservative estimate for 1982 would be $400 million. If the total increase in employment in the county rose by 140 persons, as shown in Table 1, with an average wage of $15,000 per year, total retail sales in the county might be expected to rise by about $840,000 (assuming a typical per capita expenditure of 40 percent of gross income for retail purchases). Currently, about 72 percent of all retail sales in the county occur in Wilmington (as shown in City and County figures from the 1977 <u>Census of Retailing</u>). If this same ratio holds for additional sales, then retail sales in Wilmington may rise by roughly $600,000, which is approximately 0.15 percent of the total $400 million in sales cited above. Sales tax receipts in Wilmington for fiscal year 1981-82 were estimated at $1.66 million. An increase of $600,000 in retail sales would return roughly $6,000 in tax receipts to the city, an amount which is too small to produce any noticable effect on the city's tax base.

Retailing Trade Patterns

One possible concern regarding train traffic in Wilmington is the effect that vehicle delays caused by passing trains may have on retailing activity. As background, Wilmington contains about 42 percent of the total population of New Hanover County. Wilmington per capita income is slightly below the county average. Yet in 1977, the last year for which comprehensive data is available, 72 percent of all retail sales in the county occurred in Wilmington. Thus, Wilmington is obviously the retailing center of the county. If the city had only its proportional share of trade based on personal income, retail sales in the city would be only about 55 percent of what they now are.

The loop configuration of the Belt Line from the railroad bridge across the Cape Fear River to the State Port encompasses the central business district but does not include the major shopping centers built on larger properties in the peripheral parts of the city. The effect of periodic interruptions of vehicular traffic by trains along this route would be similar to increasing the physical distance between the part of the city inside the Belt Line and that outside the loop. This model reflects the traffic engineering view that the motorist considers time as one cost of travel. As estimate of private costs due to vehicular delays is provided in the section on delay impacts.

It can be assumed that based on geographic locations of retail businesses in Wilmington (particularly the large shopping centers and highway strips), the absence of major retailing chains in the downtown area, and travel times, that purchases made in Wilmington by non-city residents tend to occur in areas outside of the Belt Line. Within the city, peripheral shopping centers will probably increase their share of sales to city residents who live outside of the Belt Line because these residents will tend to develop travel patterns to avoid being delayed by trains as they drive to or from stores in the loop. Conversely, stores within the Belt Line may increase their share of sales to residents who also live inside for reasons comparable to those advanced above. For city revenues as a whole, any redistribution of retail sales is likely to be a zero sum gain--a redistribution of sales within the city boundaries.

Property Values

The addition of unit trains to Belt Line traffic will cause negative impacts on property values in the city primarily due to increased noise and vibrations. As explained in the noise and vibration analyses, the effects will be most apparent in areas of the city within 1,000 feet of the Belt Line. The determination of

property decline assumes that as average noise levels in a neighborhood rise above ambient levels (50 dBA), there is a direct and perceived effect on the quality of life in that neighborhood. In a detailed study concerning this relationship in Springfield, Virginia it was found that property values declined approximately 0.23 percent per dBA above ambient levels. As discussed in the section on noise impacts, the expected noise level increase from unit train movement in Belt Line neighborhoods will be roughly 14 dBA. If the .23 percent decline factor is applied to this decibel figure, a value results of 3.2 percent or $32 per $1,000 of property value for residences in the 1,000 foot zone.

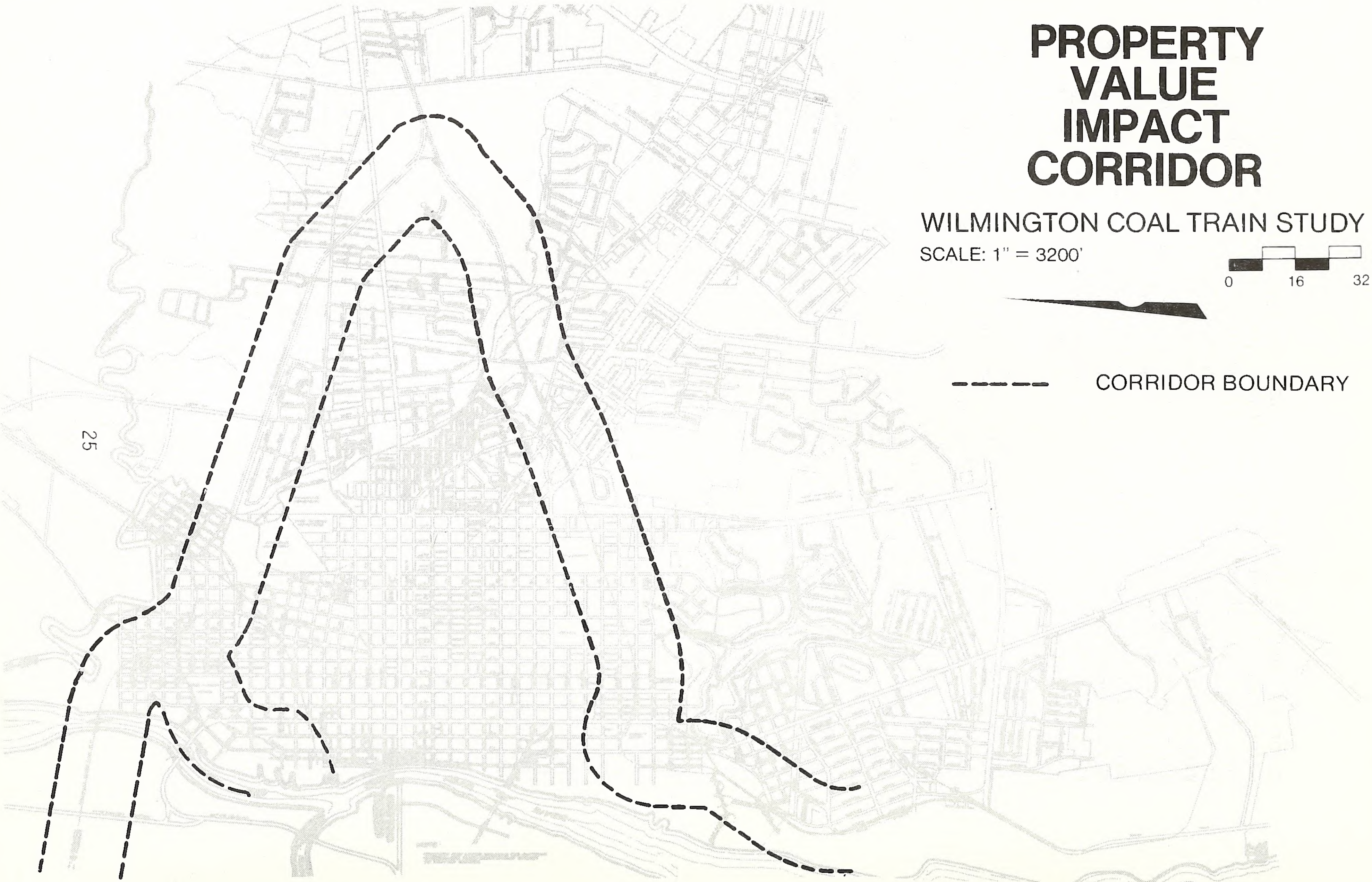
Based on housing statistics developed in the section on neighborhood impacts, it is estimated that total property value declines could amount to $1,045,137. Average value losses per housing unit would be approximately $405.00 which is a considerable cost for individual property owners. In terms of the tax impacts on the city, the losses involved will not be very significant, amounting to approximately $9,928, and it is unrealistic to assume that lowered values would be promptly reflected in assessments. On the other hand, this figure does not acount for the recurrent nature of tax losses from year to year.

Travel Delay Costs

As shown in the section on Traffic Impacts, unit train movements on the Belt Line could delay driving times on city streets by approximately 509 to 809 hours per day depending on train lengths and operating speeds. It is estimated that these delays would have a negative economic value to drivers and passengers ranging from $679,800 to $1,095,000 annually. Additional allowance for fuel operating costs incurred during delays indicates a range of $84,839 to $136,656 annually, again depending on train lengths and frequencies. Reference should be made to the Traffic Impacts section for estimation methods.

Public Facility Costs

An analysis made in the section on unit train impacts on underground utilities indicates that there may be substantial utility replacements required to upgrade the loading capacities of various water, sewerage and storm drainage mains located beneath sections of the Belt Line track. Calculations presented in that section indicate a conservative replacement cost of $315,000, if loading problems are confirmed for pipe shown.


PROPERTY
VALUE
IMPACT
CORRIDOR
WILMINGTON COAL TRAIN STUDY
SCALE: 1" = 3200'
0
16
32
CORRIDOR BOUNDARY

MAP 2

Comparsion Summary of Beneficial and Negative Impacts

Based on the analysis presented above, economic factors related to a State Port coal facility may be summarized as follows. All factors shown reflect upper limit impacts where a range of impacts were presented in the analysis:

Beneficial Impacts

1. Creation of 140 new jobs in facility and local economy service section.
2. Population increase of 155 persons.
3. Formation of 55 new households.
4. Private wages of $2,100,000.
5. Increase in retail sales of $840,000.

Negative Impacts

1. Property value declines along Belt Line of $1,045,137.
2. Annual traffic delay costs of $1,095,000.
3. Annual increase in fuel operating costs of $136,656.
4. Public utility replacement costs of $315,000.

The economic impacts should not be considered as comparible in relative effects. The positive impacts, for example, would accrue to some extent to persons presumably not living in Wilmington. Negative impacts, by contrast, will occur only to existing residents.

A Note on the Economy of the State

For North Carolina, coal trade through the port of Wilmington can be considered economically desirable although further investigation might reveal other port development projects that would be more beneficial. Since coal is not produced in any sizable quantities in the state, it has no direct benefits as an export other than port transport fees. Also, it should be

considered that it is a one-way commodity.

Revenues accruing to the state include dockage fees, land rental at the state port, a charge per ton on coal loaded at the port, corporate income taxes paid by the railroad and a franchise tax on railroad property. Precise figures on the facility in Wilmington are not available but figures quoted by the North Carolina Department of Natural Resources and Community Development for Morehead City furnish an order of magnitude estimate. The figures cited include dockage fees of $4,000 per day. At 25,000 tons per day, a ship would be loaded in about two days. About 180 ships a year would thus each pay an $8,000 dockage fee. A charge of $.50 per ton for the first two million tons per year and $.25 above that were also quoted for Morehead City. In addition a land rental at the state port in the range of $1 million annually was quoted. Increases in the yield from corporate income tax paid by the railroad and increased franchise tax resulting from higher assessed values on railroad property cannot now be estimated.

BELT LINE TRACK INSPECTION

BELT LINE TRACK INSPECTION

A visual track inspection of the Wilmington Belt Line was made on April 17, 1982 in accordance with standards prescribed in the Federal Railroad Safety Act of 1970 as amended. The general findings are summarized in this section. A more detailed listing follows with defect areas identified by general location using street intersection references.

Description of Study Area and General Approach

The Belt Line inspection included track beginning at the Front Street entry to the Port area and proceeding over the entire Belt Line loop back to the Hilton Bridge. The inspection was made on foot. The standards applied to the inspection were for Class I track as summarized in Figure 2.

The inspection standards have been developed by the railroads and the Federal Railroad Administration (FRA). FRA standards are considered minimums. In many cases, railroads have internal standards that are more strict than the FRA minimums.

The determination of track class is made by the railroad and it is this designation that governs maximum permissible operating speeds. The lower the track class, the less rigorous are the standards by which it is judged. If a railroad designates a section of track at a higher track class, and it is found on inspection that the track does not meet the requirements of that class, the railroad must either initiate physical improvements and operating modifications prescribed in FRA standards or it must re-classify the track to a lower class in which it meets the minimum standards. Again, if the track class is lowered, the maximum allowable operating speed is reduced.

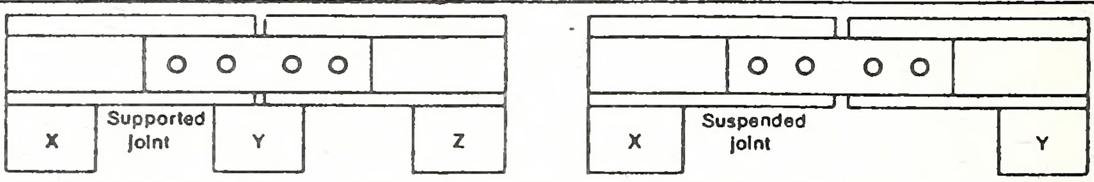
General Findings

The Wilmington Belt Line is classified by Seaboard Coast Line as Class I track. The maximum permissible operating speed for Class I track is 10 miles per hour.

The general condition of the Belt Line is not unusual for older track in urban areas but, as noted below, there are some dangerous defects which can lead to derailments. The avoidance of derailment conditions are a main consideration of FRA standards.

It should be emphasized that the findings of a failure to meet certain prescribed standards does not mean that operations

Refer to	Subject	Class Track	1	2	3	4	5	6
213.9(a)	Operating Speed Limits	Miles per hour: Freight	10	25	40	60	80	110
		Miles per hour: Passenger	15	30	60	80	90	110
213.53(b)	Gage	At least 4′ 8″ but not more than: Tangents	4′ 9¾″	4′ 9½″	4′ 9½″	4′ 9¼″	4′ 9″	4′ 8¾″
		At least 4′ 8″ but not more than: Curves	4′ 9¾″	4′ 9¾″	4′ 9¾″	4′ 9½″	4′ 9½″	4′ 9″
213.55	Alinement	Tangent—Deviation of mid-offset of 62′ line, not more than	5″	3″	1¾″	1½″	¾″	½″
		Curve—Deviation of mid-ordinate of 62′ chord, not more than	5″	3″	1¾″	1½″	⅝″	⅜″
213.63	Track Surface	Runoff in any 31′ of rail at end of a raise, not more than	3½″	3″	2″	1½″	1″	½″
		Deviation from uniform profile, either rail, mid. ord. of 62′ chord, not more than	3″	2¾″	2¼″	2″	1¼″	½″
		Deviation from designated elev. on spirals, not more than	1¾″	1½″	1¼″	1″	¾″	½″
		Variation in cross level on spirals in any 31′, not more than	2″	1¾″	1¼″	1″	¾″	½″
		Deviation from 0 cross-level at any pt. on tangent or from designated elev. on curves between spirals, not more than	3″	2″	1¾″	1¼″	1″	½″
		Difference in cross-level bet. any 2 pts. less than 62′ apart on tens. & curves bet. spirals, not more than	3″	2″	1¾″	1¼″	1″	⅝″
213.109(c)	Crossties	Minimum no. non-defective timber ties per 39 ft. of track	5	8	8	12	12	14
		Maximum distance between non-defective ties, center-to-center	100″	70″	70″	48″	48″	48″
213.109(d)	Crossties	Minimum No. of non-defective ties under a rail joint	1	1	1	2	2	2
		Required position of non-defective ties: Supported joint	X,Y or Z	Y	Y	X & Y or Y & Z	X & Y or Y & Z	X & Y or Y & Z
		Required position of non-defective ties: Suspended joint	X or Y	X or Y	X or Y	X & Y	X & Y	X & Y



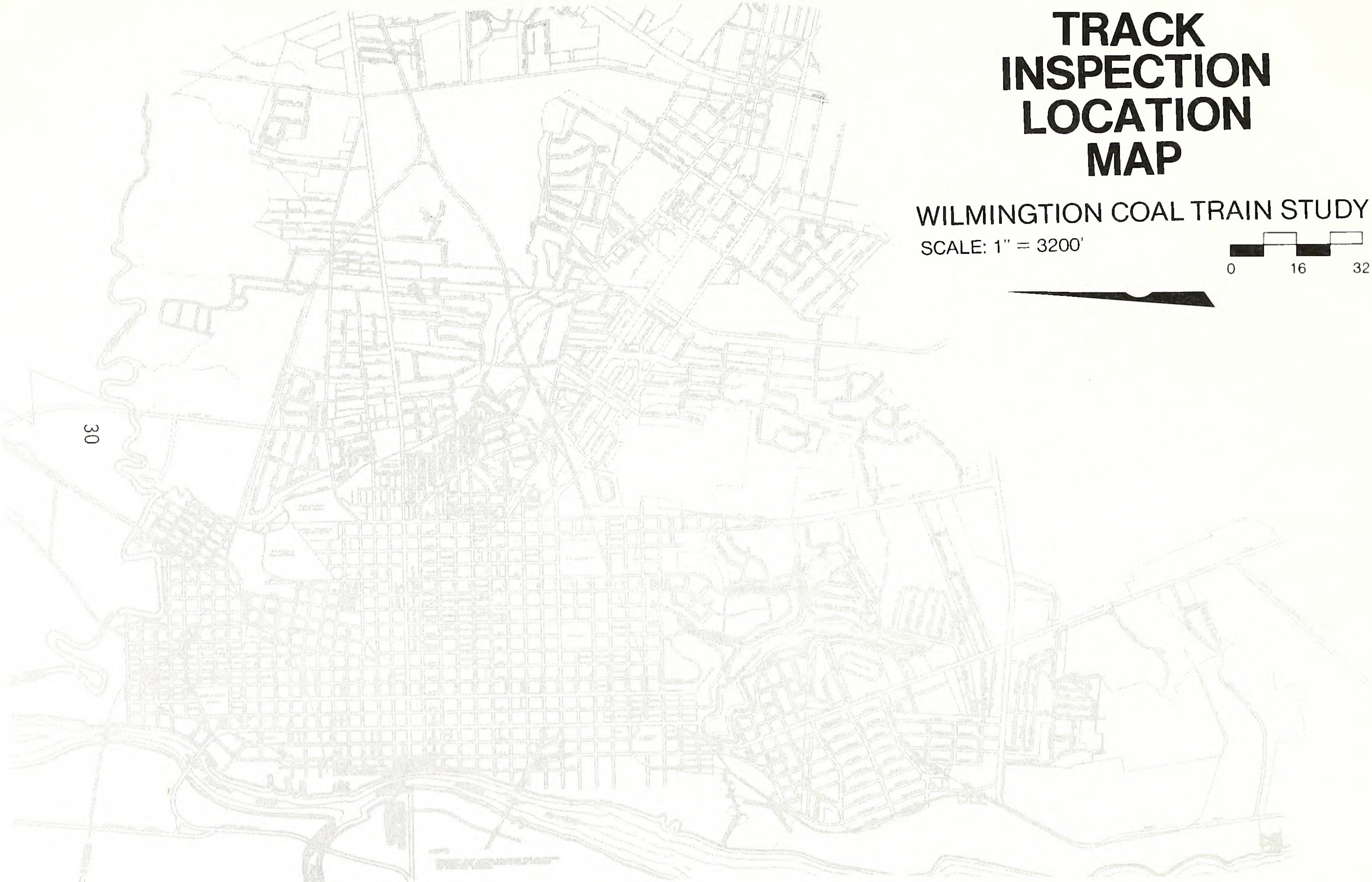
Refer to	Subject	Class Track	1	2	3	4	5	6
213.115	Rail End Mismatch	Not more than: Tread of rail ends	¼″	¼″	3/16″	⅛″	⅛″	⅛″
		Not more than: Gage side of rail ends	¼″	3/16″	3/16″	⅛″	⅛″	⅛″
213.117(b)	Rail End Batter	Not more than	½″	⅜″	⅜″	¼″	⅛″	⅛″
213.127(a)	Spikes	Total number per rail per tie incl. plate-holding spikes, at least:						
		Tangent and curves not more than 2°	2	2	2	2	2	2
		Curves, more than 2° not more than 4°	2	2	2	2	3	—
		Curves, more than 4° not more than 6°	2	2	2	3	—	—
		Curves, more than 6°	2	3	3	—	—	—
213.143	Frog guard rails & guard faces; gage	Guard check gage, not less than	4′ 6⅛″	4′ 6¼″	4′ 6⅜″	4′ 6⅜″	4′ 6½″	4′ 6½″
		Guard face gage, not more than	4′ 5¼″	4′ 5⅛″	4′ 5⅛″	4′ 5⅛″	4′ 5⅛″	4′ 5″
213.233(c)	Track Inspection Schedule	cd = calendar day interval between inspections, at least	Main track & sidings: *Weekly* (3 cd) or *Before use*, if used less than weekly, or *Twice weekly*, if has psgr trains or more than 10 MGT last cal. year. Other than main track and sidings: *Monthly* (20 cd)			All track: *Twice weekly* (1 cd)		

Figure 2. FRA Inspection Standards.

TRACK INSPECTION LOCATION MAP

WILMINGTION COAL TRAIN STUDY

SCALE: 1" = 3200'



MAP 3

must cease until a defect is corrected. Generally, a railroad can continue to operate traffic during times when track is in the process of being restored as long as the track is under the continuous supervision of railroad personnel who are qualified to pass judgement on track conditions.

The most prevalent problem found in the visual inspection is the poor condition of the crossties. There are three basic conditions that constitute a non-effective tie situation for Class I track. First, there should not be more than five non-effective ties in each 39-foot section of jointed track. Second, the maximum distance between non-effective ties should not exceed 100-inches from center to center. Third, standards allow no more than one non-effective tie per track joint (i.e., where track lengths are joined). Non-effective ties that exceed standards can cause the track to deflect, spread, or break under the weight of a train. Any of these conditions can cause derailments.

At least seventy-five cases were noted during the inspection that indicated non-effective tie problems. The areas where these defects occur most prevalently (proceeding from Front Street near the Port area) are found from 7th Street to Forest Hills Drive, Covil Avenue to Market Street and 30th Street to King Street. It should be emphasized, however, that except for a short stretch of track between 13th Street West and McRae Street, in the area of the old Atlantic Coast Line switching yard, the tie conditions on the entire Belt Line are generally in poor condition. Based on visual inspection, it is estimated that renewal will require replacement of approximately 700-800 ties per mile of track. This figure translates to roughly 25 percent of the existing ties.

There a number of track problems that should be of particular concern. The mention of these, however, should not detract from the correction of other problems noted in the detailed inspection notes.

In several instances gage defects were found. Gage is measured between the heads of the rails, beginning at a point five-eighths of an inch below the top of the rail head. In other words, it is a specified range of separation between the two tracks that support a train. For Class I track, the gage must be at least 56 inches but not more than 57.75 inches. If a gage failure is not corrected, a derailment will eventually occur.

Four gage defects were noted on the Belt Line. At 5th and Martin Streets, gage was measured at 58.25 inches at the street crossing. Approximately 156 feet east of 5th Street a second gage defect of 58 inches was found. Between Covil Avenue and Market Street, approximately 156 feet into the track curve from the point of the switch, the track is moving roughly one-half inch under load, which causes the gage at that point (57.25 inches) to exceed

the maximum. Immediately east of the McRae Street overpass, a gage defect of 58 inches was found (the rail is worn out in this area).

In addition to gage problems, there are other defects that need immediate attention. Approximately 312 feet east of Forest Hills Drive a broken rail in the joint area was noted. This could quickly develop into a derailment hazard. The tie conditions are very poor around the 30th Street intersection, at the entry of the Creekwood neighborhood. Joint bars (the devices that are used to bolt sections of track together) are generally loose along this area of track and there are numerous quarter breaks in the joint bars. The Burnt Mill Creek bridge also has extremely poor tie conditions. If a derailment occurred near the bridge, it could tear into large exposed concrete pipe sections of the city sewerage system.

Track Upgrading

Most of the conditions noted above can be corrected quickly by track crews. Complete tie renewal can be made at a rate of 1,200 to 1,500 ties per day.

A much more extensive program would be required for the Belt Line to accommodate unit coal train traffic. Almost all of the existing rail would have to be replaced with 132-pound rail. Under present conditions, improvements cannot be made to the existing track to allow regular unit train service.

The Seaboard Coast Line has indicated its intention to install the heavier rail if coal export trade develops. The railroad intends to renew ties during the 1982 summer months.

Detailed Inspection Notes

Proceeding from Front Street near the SCL entry point at North Carolina State Port.

1. Front Street to 2nd Street

   Frog point is hitting. Indicates train is not being routed smoothly onto desired track section, possibly leading to misdirection and derailment.

2. 5th Street and Martin Street

   Gage failure. Gage at 5th Street crossing is 58-1/4 inches. Maximum allowable gage is 57-3/4 inches for Class I track. Gage failure is extremely hazardous and will result in derailment if not corrected.

3. 5th Street to 6th Street

   Non-effective tie failure.

   Gage Failure approximately 156 feet east of 5th Street.

   Gage is 58 inches. Maximum allowable is 57-3/4 inches. Gage failure is extremely hazardous and will result in derailment if not corrected.

4. 5th Street to 7th Street

   Drainage culvert is plugged with sand and debris.

5. 7th Street to 13th Street

   Six non-effective tie failures.

6. 13th Street to 16th Street

   Four non-effective tie failures.

7. 17th Street to Wrightsville Avenue

   Three non-effective tie failures.

8. Wrightsville Avenue to Colonial Drive

   Two non-effective tie failures.

9. Colonial Drive to Forest Hills Drive

   Two non-effective tie failures.

10. Forest Hills Drive to Mercer Avenue

    Broken rail in joint area approximately 312 feet east of Forest Hills Drive may develop into a derailment hazard.

    Non-effective tie failure east of trestle.

11. Mercer Avenue to Covil Avenue

Track washout is developing near Covil intersection. Not serious yet, but will worsen if track drainage is not corrected.

12. Covil Avenue to Market Street

Between Covil and south point of railroad curve, at least eight non-effective tie failures.

Gage defect four rails north from point of switch at curve. Track gage is 57-1/4 inches but is moving under load an additional one-half inch.

Between north point of curve and Market Street, two non-effective tie failures.

13. Market Street to Sycamore Street

Four non-effective tie failures.

14. Evans Street and Princess Place Drive

Indication of non-effective ties below soil cover.

15. Evans Street to 30th Street

Tie conditions are very poor around 30th Street intersection.

Joint bars are generally loose along this entire section.

16. 30th Street to 23rd Street

Twenty-one non-effective tie failures.

Gage side chip at rail joint, approximately 12 rails from battery box on north rail.

17. 23rd Street to King Street

Eighteen non-effective tie failures.

Ties on and near the railroad bridge over Burnt Mill Creek are in extremely poor condition. A derailment is likely in

this area, particularly extending west from the bridge approximately two rail lengths (78 feet).

18. King Street to Hilton Bridge

Gage failure (58 inches) in track immediately east of McRae Street overpass. Rail worn out near overpass.

Two non-effective tie failures.

STREET TRAFFIC IMPACTS

Unit Train Impacts on Street Traffic Flows

The introduction of unit trains on the Wilmington Belt Line will substantially increase the amount of rail traffic through the city, causing traffic delays that are not presently factors in street traffic flow. Currently, there is only a single train per day that travels the entire Belt Line loop, from the Navassa switching yard to the State Port. Four additional trains, each roughly two to three times the length of the present single train, will be required to move coal tonnage for a 9 million ton facility at the State Port.

The analysis of train and street traffic conflicts requires a complicated modeling procedure using computer simulation. While the procedure used is explained in more detail below, the main consideration required of the simulation is that the Belt Line crosses many city streets, many of which extend over significant portions of the Belt Line loop. This means that blockage of any crossing will affect not only the street crossed by the train but traffic patterns on numerous feeder streets as well.

Three operating scenarios for train lengths and speeds were evaluated to determine probable unit train impacts on traffic flows. These included 2,000 foot and 4,000 foot train lengths and differences in maximum operating speeds of 10 and 20 miles per hour.

The resulting analyses that follow and related tables showing traffic flow impacts are necessarily complex due to the large amount of traffic data investigated. The analyses are further complicated by accounting for possible variations in train lengths, speeds, and frequencies of operation.

The data presented in the tables should be used by persons concerned with specific impacts on particular streets or areas of the city. Some of the more important findings of the detailed investigations are listed below:

1. The length of the Belt Line, its single track construction, and the loop configuration and consequent speed restrictions allow under the "worst" conditions the possibility of no more than one train during the morning or during the evening rush hours.

2. The intersections of Market Street and 30th Street and 16th Street and Dawson Street will be the areas most severely affected in terms of vehicle delays.

3. The neighborhood area that should be of particular

concern is the Love Grove section of Brooklyn Assembly since residents have no alternative entry or departure except by King Street. The Belt Line crosses King Street at the street's immediate point of entry into the neighborhood. As noted in the report section on Emergency Vehicle Impacts, the Love Grove access constraint also raises serious problems related to public safety should a derailment occur at King Street.

4. On a daily basis, during the Monday through Friday work week, unit train operations can be expected to cause total traffic delays ranging from 433.20 to 730.00 hours, depending on train speeds, lengths, and frequencies.

5. The public costs of the delays are assumed to involve, at a minimum, a value for the driver's time and an increased vehicle operating expense, due to engine idling. For purposes of analysis, a $6.00 per hour value is used for driving time. This reflects an average of minimum wage and typical skilled labor compensation in the labor force. It is recognized that individual values of time may vary substantially. Given this value the annual increase in driving time costs can be expected to range from $679,800 to $1,095,000, again depending on train speed, length, and frequency. Public costs due to engine idling during delays can be expected to range annually from $84,839 to $136,656, assuming fuel costs of $1.30 per gallon.

6. The city's legal authority to regulate unit train operations is limited to train speeds and then, only insofar as operating safety is not violated, as determined by the railroad. The matter of scheduling, train lengths and other operating procedures must be accomplished by negotiation with Seaboard officials. The variations in train operations considered in the analyses take into account a practical range of options.

Detailed Explanation of Methodology and Traffic Flow Analyses

The Network Simulation Model (NETSIM)

The evaluation of street traffic flow impacts of unit coal train operations was accomplished through the use of a specialized adaptation of the NETSIM traffic model. This program is used widely in highway planning studies since it has the capacity to make system-wide evaluations of city traffic flows. Given street designs and traffic counts, the model computes, for individual vehicles, their movement through the street network based on type of vehicle (e.g. automobile, bus, or truck),

average speed, acceptable distance between other vehicles, probable lane switching behavior, build-up of lines of traffic and discharge of these queues as, for example, acceleration after signal clearance at a street intersection.

The adaptation of the NETSIM model to Wilmington was accomplished by treating a unit train as a vehicle which always has a "green light" when it crosses any part of the city's street network. Thus, in the case of a 4,000-foot train traveling at 10 miles per hour, the train will occupy a rail and street intersection 272 seconds, which has the same effect as a red light which lasts 272 seconds (4.5 minutes). Since it will take a unit train traveling at 10 miles per hour over one-half hour to cover the Belt Line distance, it can be assumed that no more than one train per hour will be in operation on the Belt Line (also considering the track capacities at the State Port). An increase in train speeds to 20 miles per hour does not significantly affect this assumption. Once the train clears the intersection after the 4.5 minute delay, the intersection vehicle traffic flow is treated as though it has a "green" signal for the remaining 55.5 minutes (3228 seconds) of the hour. Using this general concept, the computer model is then able to simulate traffic effects if train speeds or lengths are changed.

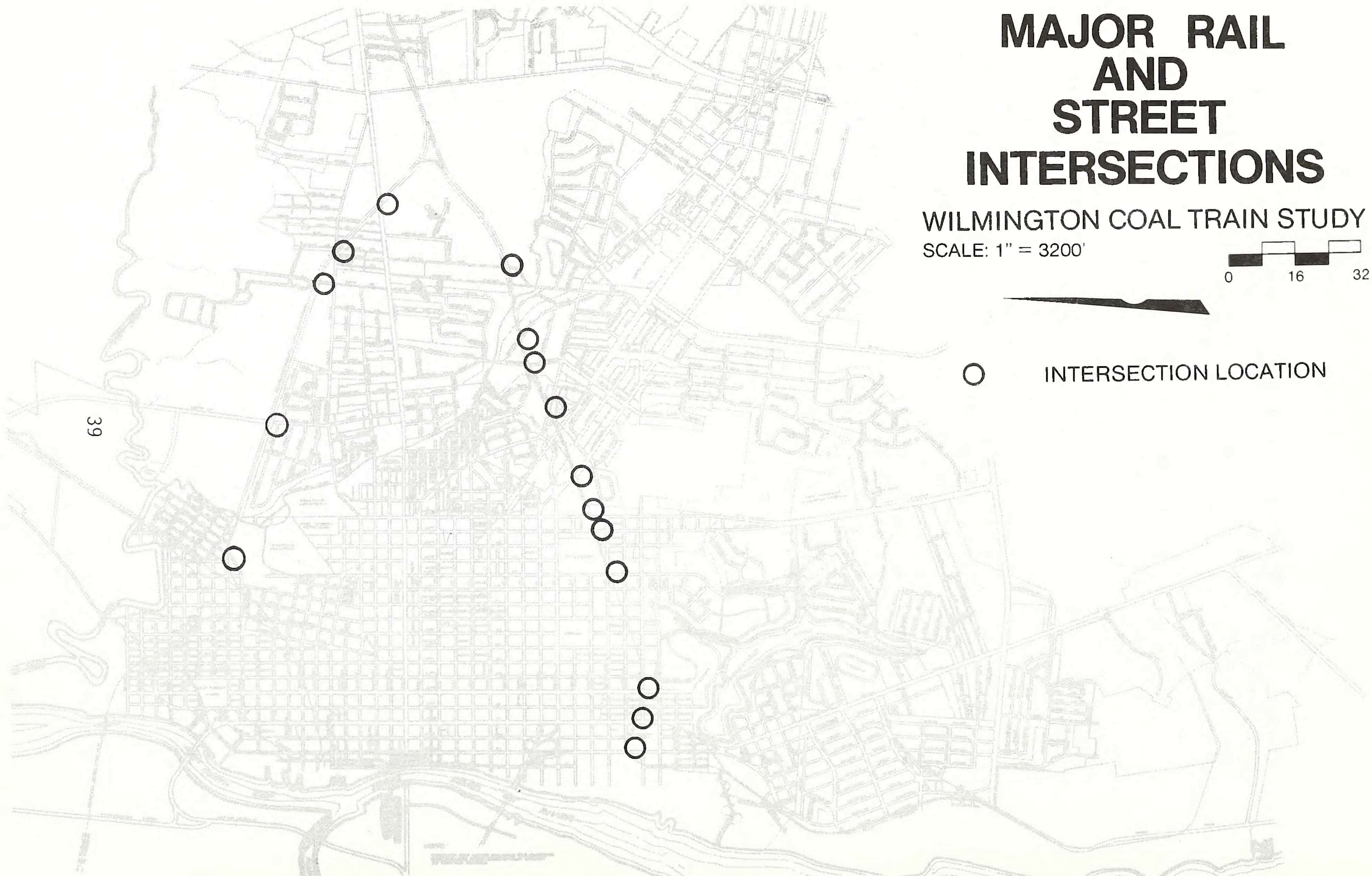
Description of Network Traffic Data and Assumptions

Train Characteristics

As mentioned in earlier report sections, operating procedures of the Seaboard Coast Line indicate that a 70 car unit train (i.e., a train having identical car types and freight) will be the typical equipment used to serve a coal export facility. Each car will have 100 tons capacity. The total train length, including four diesel engines and an allowance for slack, would be approximately 4,000 feet. Given the physical configuration of the Belt Line loop and assuming necessary track upgrading to accommodate the heavier unit train, it is estimated that speeds are limited to 10-20 miles per hour over the seven mile length from the Hilton Bridge to the State Port (see Map 4). The use of 70 car trains would require an average of four trains per day to serve a 9 million ton (annual) coal export facility at the State Port.

Street Traffic Characteristics

The street traffic data used in the NETSIM models concentrates on major arterials in the city identified by the Wilmington Planning Department as the most critical to street



MAJOR RAIL
AND
STREET
INTERSECTIONS
WILMINGTON COAL TRAIN STUDY
SCALE: 1" = 3200'
0
16
32
INTERSECTION LOCATION

MAP 4

traffic flows. These are shown on Map 4.

For each rail and street intersection, data was collected by the Planning Department on approach lengths, number of street lanes, lane configurations, speed limits, signal timings, and turning percentages. Daily traffic counts were made by the Planning Department for each of the primary streets that cross the Belt Line and for feeder streets.

The traffic counts indicate that the morning peak hour (7:30 - 8:30 a.m.) and afternoon peak hour (4:30 - 5:30 p.m.) traffic together constitute approximately 24 percent of the total daily traffic from 6 a.m. to 10 p.m. Each off peak hour from 6 a.m. to 10 p.m. accounts for approximately 5.5 percent of daily traffic. The hours of 6 a.m. to 10 p.m. are considered the normal traffic day (i.e., the times most critical to timely business and residential journeys) and are used to calculate delay times for unit train movements.

Operational Scenarios

Three operational models were designed to evaluate the effect of unit train impacts on street traffic flows. These options, listed below, provide a reasonably comprehensive testing of traffic effects due to numbers of trains, lengths and speeds, given the physical characteristics of the Belt Line. Each scenario assumes the continued operation of the present 2,000 foot mixed freight train that travels daily on the Belt Line from the Navassa switching yard to the State Port.

Scenario 1: Daily operation of four 4,000 foot unit trains traveling at 10 miles per hour for a total of 10 one-way trips. It is assumed that a single trip will occur in the morning and in the evening rush hours.

Scenario 2: Daily operation of one 2,000 foot train (i.e., a split unit train), at a speed of 20 miles per hour during the morning and evening rush hours. The remaining trips per day will consist of two 2,000 foot trains and three 4,000 foot trains, traveling at speeds of 10 miles per hour. This operation will require a total of 12 one-way trips.

Scenario 3: Daily operation of four 4,000 foot trains traveling at speeds of 20 miles per hour,

for a total of 10 one-way trips. It is assumed that a single trip occurs in the morning and in the afternoon rush hours.

Delay Results

The total vehicular delay, average delay per vehicle, and changes in total delay were provided from the NETSIM runs for 16 streets crossed by the railroad. The results are shown in Tables 3, 4, and 5 for each scenario of train operations.

The analysis was extended to an evaluation of the effects of the operating scenarios on the nine other critical intersections that are connected to the major streets crossing the railroad. The vehicular flow rates, total delay and average delay per vehicle for these intersections are shown in Table 6. The intersection of Market Street and 30th Street and the intersection of 16th Street and Dawson Street were found to be two bottlenecks in the system under the existing conditions. The introduction of a unit train on the Belt Line would substantially worsen these traffic flows.

To evaluate what would happen to traffic delays if trains speeds are increased, an incremental analysis was conducted between scenarios 1 and 3 as shown in Table 7. The results indicated that for most intersections, even a 10 mile per hour increase in train speeds would result in very significant decreases in traffic delays.

The results of the off-peak traffic simulation delays are shown in Tables 8 and 9. A comparison between the increase in total delay for the P.M.-peak (Tables 3, 4, and 5) and the off-peak (Table 8) shows that the peak delay will be much greater than would expected solely on the basis of differences in traffic volumes during the two travel periods. This is due to differences in the traffic dispersal rates of shorter and longer lines of traffic.

The delay impacts for Scenario 1 and Scenario 3 are the same for off-peak traffic flows since train lengths and speeds for these scenarios were varied only during the peak traffic hours. The incremental total delay results for off-peak traffic due to a strategy of increasing train speeds are shown in Table 9.

The delay figures of Scenario 1 and Scenario 2 would be the same during the off-peak hours, since in both cases the trains operated during these hours will be the same length (4,000 foot) and operate at the same speed (10 miles per hour). The incremental total delay results for the off-peak period due to increasing trains speeds are shown in Table 9. It is important to point out that the observed percentage decrease in total delay due to the

strategy of speed increase from 10 miles per hour to 20 miles per hour, for the off-peak hours are higher than those for the peak hours. This conclusion was reached by comparing Table 7 versus Table 9 results. This finding may be attributed to the differences in size of queues during the peak and off-peak hours.

To evaluate the three operational scenarios, it was found necessary to estimate the total vehicle delays on a network-wide basis, and combine the peak and off-peak hour results to produce daily delay results. The total traffic network delay statistics for the peak and off-peak hours were generated by the NETSIM computer model. These are shown in Table 10. The calculations are much higher than the sum of the individual intersection values shown in Tables 3, 4, 5, and 8 because the delay due to vehicle acceleration on the links leaving the intersections were not accounted for in the above mentioned tables. The average daily delays are shown in Table 11 for each scenario. In the section below, these delays are translated into public costs. The average delays assume that the probability of any train arriving to the Belt Line is the same for all hours of the day.

Travel Delay Costs

As discussed in the section on economic benefits, the loss in travel times due to vehicle delays will generate both direct and indirect public costs. Various measures to translate delays into tangible dollar amounts have been used in transportation studies; however, since people value their time differently, it is impossible to assign a value that precisely accounts for each person's delay costs.

A general conversion factor of $6.00 per hour is currently being used in highway research to account for travel delay costs. This figure was applied to delays in Wilmington. A vehicle occupancy factor of 1.37 was used to account for average passenger loads (as developed from city traffic surveys). Annual delay costs were restricted to delays for the five-day work week, (excluding Saturday and Sunday delays) and, thus, may be considered a conservative accounting of costs.

In addition to costs of time, train induced traffic delays will also cause an increase in fuel consumption due to greater engine idling time and starting and stopping operations. According to the U.S. Department of Transportation of Highway Statistics Division, the increased fuel consumption would be expected to average .576 gallons per hour of vehicle delays. Average fuel costs can be figured at $1.30 per gallon.

The grand totals for daily traffic delays and projected annual costs follow for each scenario of train operations.

Scenario 1:

Total daily traffic delay hours	=	730.00
Annual Driving Time Costs	=	$1,095,000
Annual Costs for Increased Fuel Consumption	=	$136,656

Scenario 2:

Total daily traffic delay hours	=	549.34
Annual Driving Time Costs	=	$846,300
Annual Costs for Increased Fuel Consumption	=	$102,836

Scenario 3:

Total daily traffic delay hours	=	453.20
Annual Driving Time Costs	=	$679,800
Annual Costs for Increased Fuel Consumption	=	$84,839

The totals indicate that unit train operations will result in substantial public driving time costs on a yearly basis. Given these costs, if plans are developed that lead to coal export operations at the State Port, then it is clearly in the city's interest that track speeds be increased over estimated 10 miles per hour minimums.

Table 2. PM - Peak Hourly Flow Rates at the Railroad Crossings.

Street Name	In-Bound	Out-Bound
King Street	52	52
23rd	616	420
30th*	250	282
Princess Place	347	522
Market	757	1347
Covil*	93	93
Forest Hills*	240	240
Colonial *	100	100
Wrightsville	541	974
Oleander	660	1340
17th **	1002	-
16th **	-	931
13th*	220	220
5th*	130	130
3rd	484	616
Front	301	502

*Peak Hour Counts were not available and a fixed percentage of the Average Daily Traffic was assumed.

**One-way streets.

Table 3. The Changes in the Vehicular Delays of Scenario 1* for the PM-Peak Hour (4:30-5:30 p.m.) at the Railroad Crossings

Intersection of RR Crossing and	Existing Conditions		Scenario 1		Increase in Total Delay (Vehicle Minutes)
	Total Delay (Vehicle Minutes)	Avg. Delay per Vehicle (Seconds)	Total Delay (Vehicle Minutes)	Avg. Delay per Vehicle (Seconds)	
King Street	1.80	1.00	17.37	9.65	15.57
23rd Street	401.90	19.36	893.80	43.07	491.90
30th Street	18.40	2.33	161.00	20.42	142.60
Princess Place Drive	72.00	4.86	223.80	15.12	151.80
Market Street	242.40	8.31	902.00	30.94	659.60
Covil Avenue	17.40	5.49	44.90	14.17	27.50
Forest Hills Drive	43.70	4.61	206.40	21.06	162.70
Colonial Drive	10.40	2.66	43.70	11.20	33.30
Wrightsville Avenue	84.60	3.55	450.20	18.91	365.60
Oleander Drive	213.30	6.40	859.20	25.78	645.90
17th Street	15.40	0.88	222.60	12.72	207.20
16th Street	42.00	3.82	192.10	17.51	150.10
13th Street	25.50	3.11	129.60	15.83	104.10
5th Street	10.40	2.73	72.30	18.22	61.90
3rd Street	8.30	0.45	166.80	9.21	158.50
Front Street	27.90	2.10	178.70	13.48	150.80

* A 4000-foot train travelling at 10 miles per hour.

Table 4. The Changes in the Vehicular Delays of Scenario 2* for the PM-Peak Hour (4:30-5:30 p.m.) at the Railroad Crossings

Intersection of RR Crossing and	Existing Conditions		Scenario 2		Increase in Total Delay (Vehicle Minutes)
	Total Delay (Vehicle Minutes)	Avg. Delay per Vehicle (Seconds)	Total Delay (Vehicle Minutes)	Avg. Delay per Vehicle (Seconds)	
King Street	1.80	1.00	3.60	2.00	1.80
23rd Street	401.90	19.36	540.20	26.00	138.30
30th Street	18.40	2,33	78.70	10.13	60.30
Princess Place Drive	72.00	4.86	109.30	7.49	37.30
Market Street	242.40	8.31	431.90	14.63	189.50
Covil Avenue	17.40	5.49	21.20	6.50	3.80
Forest Hills Drive	43.70	4.61	83.10	8.82	39.40
Colonial Drive	10.40	2.66	16.00	4.19	5.60
Wrightsville Avenue	84.60	3.55	123.70	5.23	39.10
Oleander Drive	213.30	6.40	401.90	12.04	188.60
17th Street	15.40	0.88	32.20	1.84	16.80
16th Street	42.00	3.82	50.70	4.71	8.70
13th Street	25.50	3.11	33.00	4.03	7.50
5th Street	10.40	2.73	16.70	4.21	6.30
3rd Street	8.30	0.45	42.20	2.32	31.80
Front Street	27.90	2.10	60.10	4.52	32.20

* A 2000-foot train travelling at 20 miles per hour only during the peak hour

Table 5 The Changes in the Vehicular Delays of Scenario 3* for the PM-Peak Hour (4:30-5:30 p.m.) at the Railroad Crossings

Intersection of RR Crossing and	Existing Conditions		Scenario 3		Increase in Total Delay (Vehicle Minutes)
	Total Delay (Vehicle Minutes)	Avg. Delay per Vehicle (Seconds)	Total Delay (Vehicle Minutes)	Avg. Delay per Vehicle (Seconds)	
King Street	1.80	1.00	4.23	2.35	2.43
23rd Street	401.90	19.36	589.80	28.42	187.90
30th Street	18.40	2.33	91.60	11.61	73.20
Princess Place Drive	72.00	4.86	161.90	10.93	89.90
Market Street	242.40	8.31	587.70	20.16	345.30
Covil Avenue	17.40	5.49	29.20	9.22	11.80
Forest Hills Drive	43.70	4.61	118.60	12.52	74.90
Colonial Drive	10.40	2.66	17.5	4.48	7.10
Wrightsville Avenue	84.60	3.55	194.20	8.15	109.60
Oleander Drive	213.30	6.40	521.60	15.63	308.30
17th Street	15.40	0.88	76.80	4.38	61.40
16th Street	42.00	3.82	79.20	7.22	37.20
13th Street	25.50	3.11	58.40	7.13	32.90
5th Street	10.40	2.73	34.40	9.05	24.00
3rd Street	8.30	0.45	135.50	7.48	127.20
Front Street	27.90	2.10	129.10	9.74	101.20

* A 4000-foot train travelling at 20 miles per hour.

Table 6. Vehicular Delays for the PM-Peak Hour (4:30-5:30 p.m.) at the Critical Intersections on Both Sides of the Railroad Crossings

Intersection	Existing Conditions			Scenario 1			Scenario 2			Scenario 3		
	Flow Rate (Vph)	Total Delay (Veh-Min)	Average Delay (Seconds)	Flow Rate (Vhp)	Total Delay (Veh-Min)	Average Delay (Seconds)	Flow Rate (Vph)	Total Delay (Veh-Min)	Average Delay (Seconds)	Flow Rate (Vph)	Total Delay (Veh-Min)	Average Delay (Seconds)
Princess Place and 23rd	1952	3094.70	95.12	1920	4544.30	142.00	1977	3297.80	100.00	1951	4782.40	147.07
Princess Place and 30th	1330	516.10	23.28	1290	522.70	24.31	1319	524.00	23.83	1322	542.70	24.63
Market & 30th	2038	7098.40	208.98	1867	22097.00	710.13	1997	15562.30	708.00	1973	16466.60	500.75
Forest Hills and Colonial	701	81.70	6.99	702	209.86	17.93	693	164.90	14.27	701	171.6	14.64
Wrightsville and Colonial	1606	173.30	6.47	1603	299.60	11.21	1604	257.30	9.62	1605	289.10	10.80
Oleander and Columbus Cir.	2026	258.10	7.65	2020	629.40	18.64	2093	468.70	13.80	2050	593.70	17.40
Oleander Dawson	939	55.9	3.57	946	305.72	19.40	941	80.20	5.61	961	122.60	7.65
17th and Marsteller	1047	87.00	4.98	1056	398.10	22.61	1047	346.30	19.84	1046	326.20	18.71
16th and Dawson	1536	4514.40	176.34	1509	12472.10	495.90	1510	12283.40	488.08	1568	11466.40	438.76

Table 7. Incremental Delay Results (Vehicle Minutes) for the PM-Peak at the Major Railroad Crossings Due to Increasing Train (4,000 foot) Speed

Intersection of RR Crossing and	Decrease in Total Delay Due to Train Speed Increase*	Percentage Decrease in Total Delays (%)
King Street	13.14	75.65
23rd Street	304.00	34.00
30th Street	69.40	43.10
Princess Place Drive	61.90	27.65
Market Street	314.30	34.84
Covil Avenue	15.70	34.96
Forest Hills Drive	87.80	42.53
Colonial Drive	26.20	59.95
Wrightsville Avenue	256.00	56.86
Oleander Drive	337.60	39.29
17th Street	145.80	65.49
16th Street	112.90	58.77
13th Street	71.20	54.93
5th Street	37.90	52.42
3rd Street	31.30	18.76
Front Street	49.60	27.75

* Total Vehicular Delay of Scenario 1 - Total Vehicular Delay of Scenario 3

Table 8. The Change in the Total Vehicle Delays (Vehicle Minutes) of the Three Scenarios for the Off-Peak Hours at the Railroad Crossings

Street	Existing Conditions	Scenario 1 Total Delay	Increase in Total Delay for Scenario 1	Scenario 2* Total Delay	Increase in Total Delay for Scenario 2	Scenario 3 Total Delay	Increse in Total Delay for Scenario 3
23rd	153.40	334.50	181.10	334.50	181.10	210.40	57.00
30th	9.40	68.90	59.50	68.90	59.50	31.70	22.30
Princess Pl.	33.00	116.70	83.70	116.70	83.70	56.30	23.30
Market	119.60	494.80	375.20	494.80	375.20	235.10	115.50
Covil	10.90	33.20	22.30	33.20	22.30	13.00	2.10
Forest Hills	20.50	86.30	65.80	86.30	65.80	44.40	23.90
Colonial	5.40	25.40	20.00	25.40	20.00	9.10	3.70
Wrightsville	34.90	175.20	140.30	175.20	140.30	68.60	33.70
Oleander	90.60	378.70	268.10	378.70	268.10	194.50	103.90
17th	4.10	131.20	127.10	131.20	127.10	36.0	31.90
16th	32.30	134.70	102.40	134.70	102.40	58.80	26.50
13th	11.60	65.10	53.50	65.10	53.50	23.50	11.90
5th	5.60	21.10	15.50	21.10	15.50	12.00	6.40
3rd	3.60	103.90	100.30	103.90	100.30	57.20	53.60
Front	13.20	107.00	93.80	107.00	93.80	60.20	47.00

* Scenario 2 is identical to Scenario 1 during the off-peak hours
Negligible off-peak impacts at King Street.

Table 9. Incremental Total Delay Results (Vehicle-Minutes) for the Off-Peak at the Major Railroad Crossings Due to Increasing Train(4,000 foot) Speed

Intersection of RR Crossing with	Decrease in Total Delay Due to Train Speed Increase*	Percentage Decrease in Total Delay (%)
23rd Street	124.10	37.10
30th Street	37.20	53.99
Princess Place Drive	60.40	51.75
Market Street	259.70	52.48
Covil Avenue	20.20	60.84
Forest Hills Drive	41.90	48.55
Colonial Drive	16.30	64.17
Wrightsville Avenue	106.60	60.84
Oleander Drive	177.50	48.64
17th Street	95.20	75.56
16th Street	75.90	56.34
13th Street	41.60	63.90
5th Street	9.10	43.12
3rd Street	46.70	44.94
Front Street	46.80	45.60

* Total Vehicular Delay of Scenario 1 - Total Vehicular Delay of Scenario 3

Negligible off-peak impacts at King Street.

Table 10. Total Change in Network Delay (Vehicle-Minutes) for the PM Peak Hour and Single Off-Peak Hour During Train Movements.*

	Existing Condition	Scenario 1 Total	Scenario 1 Change	Scenario 2 Total	Scenario 2 Change	Scenario 3 Total	Scenario 3 Change
PM-Peak	23,712.1	54,307.2	30,595.1	42,077.8	18,365.7	44,780.5	21,068.4
Off-Peak	2,854.1	5,215.3	2,361.2	5,349.8	2,495.7	4,024.2	1,170.1

*Numbers shown represent single PM Peak (the highest traffic volume hour per day) and single Off-Peak hours.

Table 11. Average Daily Delay of the Total System for the Three Scenarios Based on Train Arrival Probabilities*

Scenario	Average Total Delay (Vehicle-Hours/Day)
1	730.00
2	549.34
3	453.20

*See Appendix A for calculations. This table takes into account situations in which one train may be exiting the Belt Line while another enters. It is not a sum of Table 10.

EMERGENCY VEHICLE IMPACTS

Emergency Vehicle Impacts

The evaluation of unit train impacts on fire department and rescue squad services involves determining probabilities for conflicts at rail and street intersections. The findings in this section generally indicate that delays will not be substantial in terms of probabilities, due in part to the geographic location of fire and rescue facilities and because, unlike general street traffic, there is simply far less chance that an emergency vehicle will be on a particular street being crossed by a train. Still, a discussion of probabilities should not overlook the fact that where delays do occur, these situations are usually far more significant to individuals than might be expected in cases involving work, shopping or other daily trips. Thus, even when the chances of conflict are very small (for example, less than .004 times in each response), it remains that the chance conflict could occur at any time, although statistically it is unlikely.

As with general traffic impacts, the determination of the emergency vehicle impacts requires a complex modeling of traffic patterns. Separate analyses are provided for fire and rescue vehicles. The findings summarized below highlight the detailed investigations which follow. Reference should be made to Maps 5 and 6 for service zone locations.

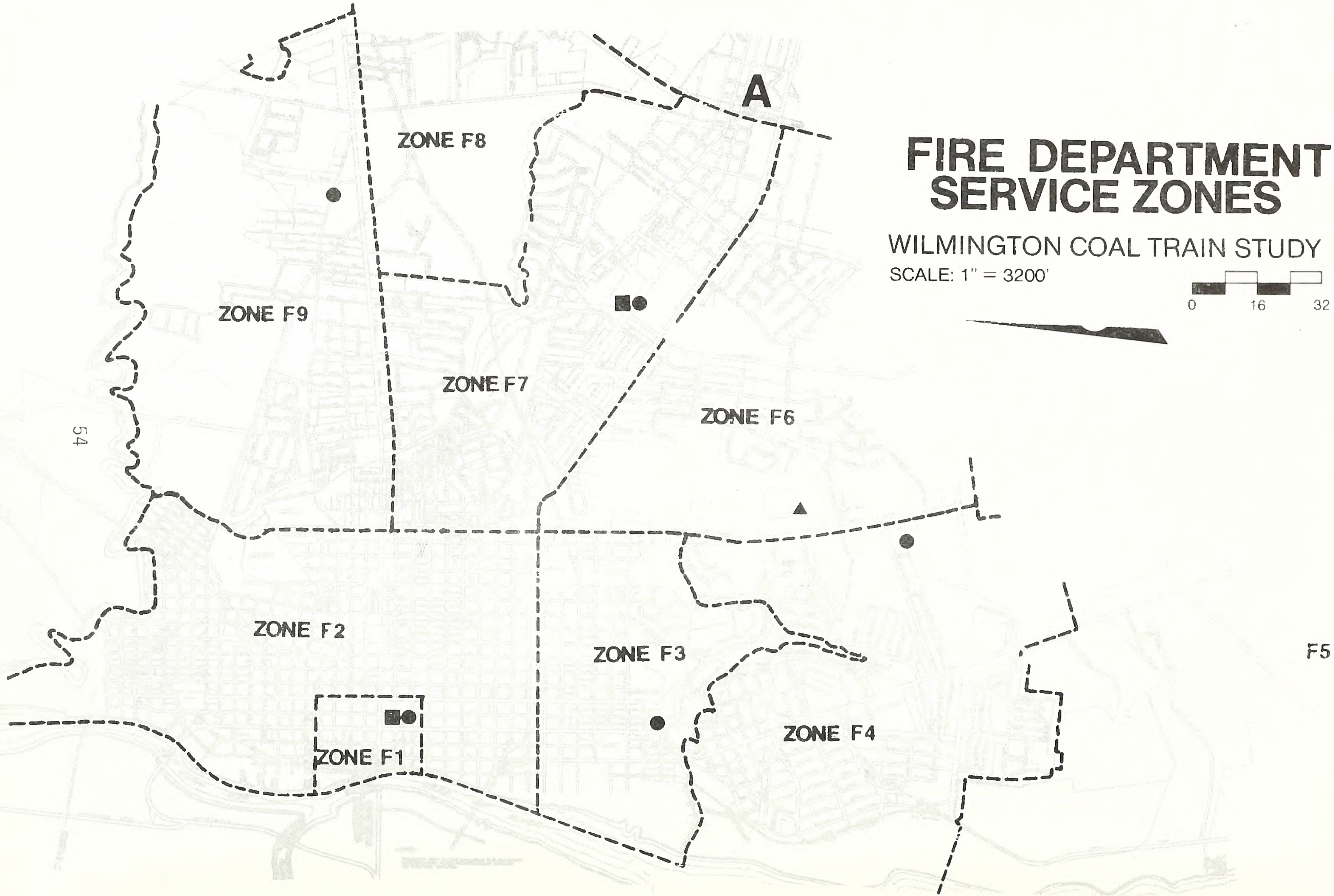
Fire Department Vehicle Conflicts

1. Due to geographic locations of the fire stations, Zones 1, 4, 5 and 10 can be served directly without conflict with Belt Line rail traffic. These zones cover the central business district and the neighborhoods of Sunset Park, South Wilmington, East Greenfield, and the University area.

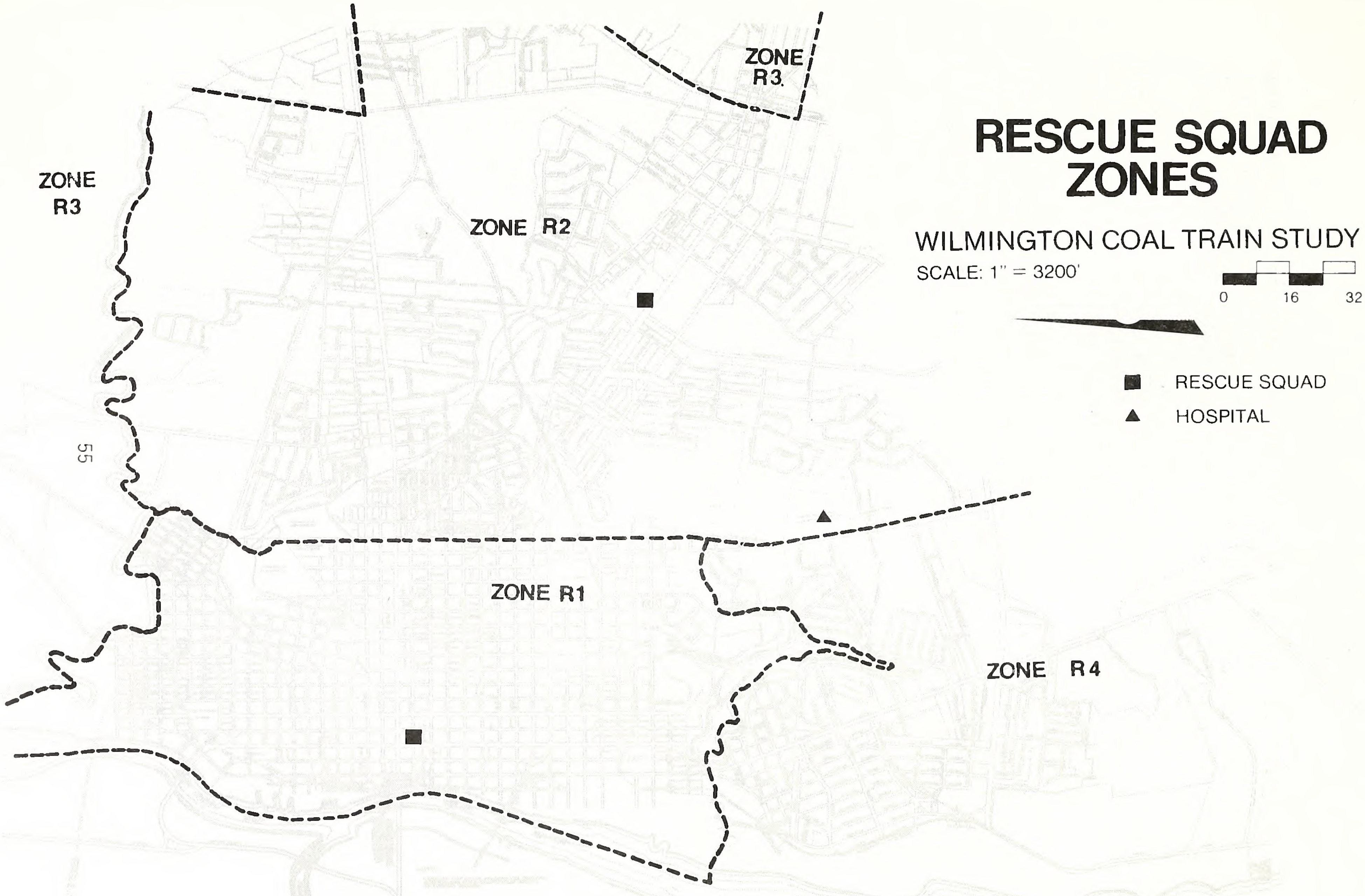
2. Zones 2, 3, 7, 8, and 9 and a small portion of Zone 6 require at least one crossing of the Belt Line. Neighborhoods served by these zones include Brooklyn, Love Grove, Northside-Market, part of Old Wilmington, the Bottom, Southside, Dry Pond, Oleander, North Lakeside, Chestnut, Wrightsville Avenue, Forest Hills, and East Wilmington. Zone 7, serving the Wrightsville Avenue area and Forest Hills, requires two crossings over the Belt Line when served by the Wellington Station back-up.

3. The maximum calculated delay for all conflicts is estimated to be 272 seconds (4.5 minutes). This time interval assumes a 4,000 foot train traveling at 10 miles per hour and the movement of fire trucks to the front of traffic lines.

4. The probability of a conflict in parts of the city covered by Fire Zones 2, 3, 7, 8, and 9 will range from .004 to .010 per


FIRE DEPARTMENT
SERVICE ZONES
WILMINGTON COAL TRAIN STUDY
SCALE: 1" = 3200'
0
16
32
A
ZONE F8
ZONE F9
ZONE F7
ZONE F6
ZONE F2
ZONE F3
ZONE F1
ZONE F4
F5

MAP 5


RESCUE SQUAD
ZONES
WILMINGTON COAL TRAIN STUDY
SCALE: 1" = 3200'
0
16
32
RESCUE SQUAD
HOSPITAL
ZONE R3
ZONE R2
ZONE R3
ZONE R1
ZONE R4

MAP 6

response (i.e., from 4 to 10 times per 1,000 calls) given average response speeds of 30 miles per hour and selection of the most direct routes from station to caller. Expected conflicts for Zone 6 are nearly insignificant - a probability of .0008 or less than 1 conflict per 1000 calls.

5. When a conflict occurs, the delay for a fire vehicle will average 136 seconds. Given the probabilities of conflicts the average delay for any fire vehicle responding to a call will range from 1.10 to 2.81 seconds.

6. The Love Grove neighborhood is the only area of the city that has no alternative entry streets for fire vehicles apart from the King Street access. A derailment at this street would leave the neighborhood isolated from fire vehicles, thus posing a potentially serious situation to public health.

Rescue Squad Vehicles

1. As with fire department vehicles, the maximum delay time is estimated at 272 seconds for all rescue vehicle conflicts.

2. The probability of train conflicts with rescue vehicles are generally higher than with fire vehicles because rescue service may require a trip both to the accident site and then to a hospital. The rescue zones affected by rail crossings are Zones 1 and 2 which include all neighborhoods in Wilmington except those south of Greenfield Lake and on the extreme peripheries of the city.

3. For Zone 1, serving the western and downtown areas of the city, the conflict probabilities will range from .0179 to .116 per trip (i.e., roughly 18 to 116 conflicts per 1,000 trips). When a conflict occurs, the average delay for a rescue vehicle will be 136 seconds and, in unusual cases, could be twice this amount (272 seconds) if a train is encountered both on the trip to the accident and on the return to a hospital. When averaged over all expected yearly trips, the average delay for any response will range from 4.87 to 31.77 seconds. The upper range indicates a serious delay time although, as noted in the detailed analysis, the chances are small for this amount of delay.

4. For Zone 2, serving the eastern areas of the city, the conflict probabilities range from .0017 to .029 per trip (i.e, roughly 2 to 29 conflicts per 1000 trips). The average delay time for an actual conflict between a rescue squad vehicle and a train is the same as in Zone 1 (i.e., 136 to 272 seconds). However, due to differences in rescue squad locations, the expected delay in Zone 2 for any response, averaged over all calls, will be much lower, ranging from .48 to 4.14 seconds.

Methods of Analysis

The general procedure for determining conflict probabilities for both fire department and emergency vehicles involved identifying coverage zones for each function, determining the primary and secondary (i.e., backup service) responsibility and establishing an estimate of future demand and average response times based on past records of operations. This information was supplied by fire department officials.

The calculation of train movement conflicts was made using the assumptions of increasing Belt Line traffic from the present single train to four additional 4000 foot unit trains. Average running speeds for the unit trains and present single train were assumed to be 10 miles per hour. These assumptions conform to the "worst" case scenario discussed in the preceding report section on traffic impacts.

Average operating speeds for the fire and rescue squad vehicles are estimated at 30 and 35 miles per hour respectively. These speeds take into account street design speeds, number of lanes, differences in fire and rescue vehicle driving requirements and passing priorities in an emergency. It is also assumed that if a fire or rescue vehicle is stopped in a line of traffic that is delayed at a rail crossing, the vehicle will pull to the front of the line (if necessary, in an opposing lane).

Detailed Analyses: FIRE STATION SERVICES

Five fire stations serve the city. These are : 1) Headquarters, 2) Willard, 3) Wellington, 4) Empie and 5) Princess Place. Each of these stations serve at least one of ten designated fire zones. At least two pumpers respond to alarms when there is a significant fire. Response is according to the following schedule:

Zone	Station from which Pumpers Respond
1	Headquarters
2	Headquarters
3	Headquarters, Willard
4	Willard, Wellington
5	Willard, Wellington
6	Willard, Wellington
7	Empie, Wellington
8	Empie, Princess Place
9	Headquarters, Princess Place
10	Empie, Princess Place

The locations of the stations and the service zones are shown in Map 5. The total number of responses by the fire engines, for a three-year period, are shown in Table 12. While the table indicates that the total number of responses is experiencing a downward trend, the analysis assumes that responses will not be any lower than 1981 levels. The number of fire alarms and the average service time per call are listed in Table 13.

Examination of the coverage of each zone and the location of the station that serves the zones, respective to the Belt Line, shows that Zones 1, 4, 5, and 10 can be served directly with no conflict with rail traffic in the area. The remaining Zones, 2, 3, 6, 7, 8, and 9 will have probabilities of conflicts, as explained below.

VEHICLE CONFLICT ANALYSIS -- Zones 2, 3, 6, 7, 8, and 9

Almost all routes in fire service Zones 2, 3, 7, 8, and 9 have at least one railroad crossing. A small portion of Zone 6 requires a crossing. Zone 7 requires two crossings over the Belt Line for back-up service from the Wellington Station. Access to the Love Grove neighborhood is severely restricted because of the single entry at King Street.

Analysis of Zone 2 conflict probabilities required dividing the zone into two sections since the southern part of the zone is accessible to Headquarters without need to cross the Belt Line. For the northern section, it was assumed for purposes of establishing average travel conditions that the fire alarms are generated from the geographical center of the section. Further, it was assumed that the alarms will be distributed equally through the total area and that the estimated number of alarms per section can be determined by considering the ratio of the approximate section area to the total zone area. The center of the northern section is estimated to be at the intersection of Howard Street and 7th Street, with the shortest path to Headquarters being 7th to Howard to 6th to Dock. The distance between the origin and destination was measured from the maps to be 7,500 feet. Average running speed is estimated at 30 miles per hour with travel time amounting to 2.83 minutes. This travel time is considered unconstrained by other traffic since fire engines have priority in an emergency.

For Zone 2, probability of a rail crossing conflict is calculated to be 0.00457 and the expected delay per response, averaged over all yearly responses, is 1.25 seconds. It is important to emphasize that the minimum delay is zero, and the possible maximum delay is equal to the train crossing time (272 seconds) in which case the probability is equal to unity (or 100%). This emphasizes the significance of train speed and train

length on the expected delay per fire engine at crossings.

Tables 14 and 15 contain all the data for the remaining fire service zones (Zones 2, 3, 6, 7, 8, and 9) from the primary and secondary stations. This information includes: 1) section description; 2) station name serving this section; 3) the locations of the geographical center of the section under evaluation; 4) the shortest path and the required travel time; 5) the probability of a rail conflict; and 6) the expected delay per fire engine. Almost all fire service routes have one railroad crossing except for a section in Zone 7 served by the secondary station (Princess Place) where the path crosses the Belt Line twice and a resulting relatively high probability value occurs.

In Zone 2 an alternate route was considered that crosses the Belt Line once but has a longer travel time. The resulting conflict probability value is half that of the shorter alternative requiring two crossings. This alternate route is recommended over the original route in spite of the longer travel time.

As a general conclusion, it appears that overall the probabilities of unit trains and fire engine crossing conflicts would be very small. At the higher range of probability, approximately 10 responses per 1000 might experience delays ranging from one to 272 seconds. When averaged over all calls, the delay per fire department response is not expected to be greater than 4.42 seconds.

Detailed Analyses: RESCUE SQUAD SERVICES

Rescue squad vehicles are dispatched from the Sheriff's Department. These vehicles are stationed at: 1) The Fire Department Headquarters Building, 2) Empie Fire Station, 3) US 17 and Military Cutoff Road (Ogden Rescue Squad), and 4) US 421 South (New Hanover Rescue Squad). The city is divided into four service zones. Two hospitals, New Hanover Memorial Hospital and Cape Fear Memorial Hospital, receive dispatched vehicles. Primary and secondary zones responses are according to the following schedule:

Rescue Squad Station

Zone	Primary	Secondary
1	Headquarters	Empie
2	Empie	Headquarters
3	Ogden	City
4	New Hanover	City
5	New Hanover	Ogden
6	Ogden	New Hanover

The number of rescue squad calls and the average service time per call, as provided by the Wilmington Fire Department, are shown in Table 16 by classification of fire alarm zones. It was assumed generally that a rescue squad call results in a trip to the nearest hospital; therefore, the analysis of rescue squad service is different from the fire service, since a second trip path is added to the analysis and increases the probabilities of conflict with trains. The rescue squad zones affected by additional trains on the Belt Line are Zones 1 and 2, which cover the city extending from the downtown area. The procedure of estimating the probability figures and the expected stopped delay is the same as that of the fire service, as shown in Appendix B.

The conflict probabilities for Zones 1 and 2 for the primary rescue squads are shown in Tables 17 and 19. Zone 1 was divided into three sections; a northern section located north of the Belt Line, a middle section located within the Belt Line, and a southern section outside of the Belt Line on the southern side. The probability of railroad conflicts and the expected stopped delays are for a total of 2,814 annual calls (the highest number of calls during 1979-1981).

As shown in Table 17, the rescue squad conflict probabilities, for Zone 1, are higher than those of the fire stations. Section 1 rescue squad route has three railroad crossings. Section 2 and 3 routes have a single crossing. The corresponding probability figures and expected stopped delay per rescue squad from the Empie station are shown in Table 18. The results of the probability analyses and the expected delay calculations for Zone 2 are shown in Tables 19 and 20 for the primary and secondary rescue squads respectively. Average travel

speeds are estimated at 35 miles per hour.

The analyses indicate that rescue squad vehicles would probably have very few crossing conflicts with unit trains, at least at the level of four additional trains per day. An exception to this finding, however, is in the case of the Empie back-up responsibilities to Zone 1 rescue operations in the Brooklyn neighborhood area (Section 1 of Zone 1). A response from Empie station to the Brooklyn area requires two crossings of the Belt Line, both in proceeding to an accident and in the case of returning to a hospital. While this back-up service is rarely used and conflict probabilities, thus, are very low, the average expected delays to rescue squad vehicles may be as high as one-half minute. This delay time could be critical in certain emergency situations. It should also be emphasized again that access to Love Grove for rescue squad vehicles, as with fire vehicles, could be a critical problem due to lack of more than one street entry into the neighborhood.

Table 12. Responses of the Fire Engines for a Three-Year Period in Wilmington, North Carolina

	1979	1980	1981
1) Headquarters			
Engine 1	543	426	477
Engine 7	1033	759	689
2) Empie Station			
Engine 2	419	418	364
3) Princess Place Station			
Engine 3	745	480	482
4) Wellington Station			
Engine 5	418	471	442
5) Willard Station			
Engine 6	991	592	538

Table 13. Number of Fire Alarms Classified by Zones

Zone #	Fire Alarms
1	227
2	885
3	385
4	549
5	27
6	214
7	345
8	104
9	348
10	41

The average time expended per call, including vehicle trip, is 19 minutes.

Table 14. Probability of a Rail Crossing Conflict and Corresponding Expected Delay for the Fire Service Zones from the Primary Station

Zone Number	Section Description	Station Name	Center of Zone or Section	Path from Station to Center Location (Minimum Path)	Estimated Total Distance (feet)	Total Travel Time (Minutes)	Probability of a Conflict	Expected Stopped Delay (Seconds)
2	North of the RR Crossing. Smith Creek to the north and Cape Fear River to west	Headquarters	Intersection of Howard and 7th	Dock 5th Nixon 6th Howard	7,500	2.83	0.00783	2.13
3	South to the RR Crossing. Cape Fear River to the west and Greenfield Lake, to south	Headquarters	On East Lake Shore Drive	Dock 5th Greenfield East Lake Shore Drive	10,800	4.08	0.01031	2.81
6	Business Triangle Bounded by 17th St., Oleander Dr. and SCL RR	Willard	N/A	3rd Dawson Oleander	9.600	3.63	0.0008	0.23
7	North of RR Crossing. Covil St. to the east and Market Street to the north.	Empie	On Colonial Drive	Park Ave. Country Club Colonial	7,400	2.80	0.00506	1.38
8	North of the Semi-closed Loop South Kerr to the West	Empie	On Greenway Avenue	4th Market South Kerr Greenway Avenue	20,800	6.73	0.00402	1.10
9	North of the Semi-closed Loop. Low-income Development on 30th Street	Headquarters	On Stewart Circle	4th 30th Market Emory Stewart Circle	16,000	5.18	0.00537	1.46

Table 14. Probability of Rail Crossing Conflict and the Corresponding Expected Delay for the Fire Service Zones from the Secondary Station

Zone Number	Section Description	Station Name	Center of Zone or Section	Path from Station to Center Location (feet)	Estimated Total Distance (feet)	Total Travel Time (Minutes)	Probability of a Conflict	Expected Stopped Delay (Seconds)
3	North of RR Crossing. Dawson St. to the north and Cape Fear River to the west.	Willard	Intersecton of 8th and Mearse Streets	3rd Greenfield 8th	4,000	1.50	0.00446	1.21
6	Business Triangle Bounded by 17th St., Oleander Dr. and SCL RR.	Wellington	N/A	Wellington to 17th Street	11,200	4.23	0.0009	0.24
7	South of RR Crossing. South Kerr to the east and Oleander to the south.	Wellington	On Hawthorne Road	*Princess Place Market E. Forest Hill Wrightsville Wilshire Hamlock	12,000	4.00	0.01623	4.42
7 (Alternate Route)	Same as Above	Wellington	Same as Above	Princess Place Market South Kerr Wilshire Hamlock	16,000	5.18	0.00821	2.24
7	North of RR Crossing. Covil to East Market St. to the north.	Wellington	On Colonial Drive	Princess Place 30th Market Colonial Dr.	7,200	2.72	0.00506	1.38
8	North of the Semi-closed loop. South Kerr to the west	Princess Place	On Greenway Avenue	Princess Pl. Market South Kerr Greenway	7,200	2.72	0.000943	0.26
9	South of the RR Crossing. Market St. to the south and 17th St. to the west	Princess Place	On Kenwood Avenue	Princess Place Kenwood Ave.	5,800	2.19	0.00080	2.18

* Crossing the railroad track twice.

Table 16. Number of Rescue Squad Calls Classified by Zone

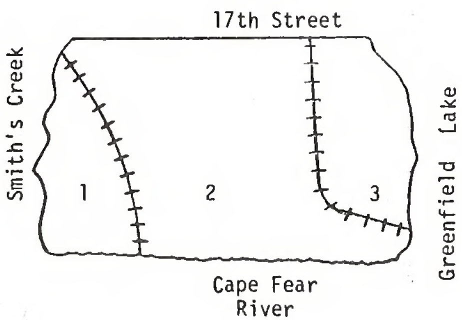
Zone #	Rescue Squad Calls
1	247
2	1752
3	815
4	266
5	2
6	211
7	417
8	217
9	401
10	46

The average time per call is 23 minutes.

Table 17. Probability of a Rail Crossing Conflict and the Corresponding Expected Delay of Zone 1 fcr the Rescue Squad from the Primary Station

Section Description

Section #	Center
1	Howard & 7th
2	Orange & Eighth
3	East Lake Shore



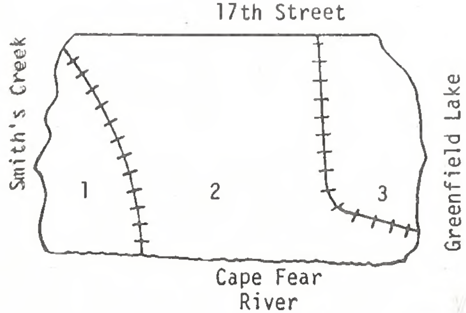
Section #	Area %
1	32.67
2	50.50
3	16.83
	100.00

Station	From Station to Caller			From Caller to the Nearest Hospital				
	Path	Distance (feet)	Travel Time (minutes)	Path	Distance (feet)	Travel Time (minutes)	Proba-bility of Conflict	Expected Stopped Delay (seconds)
Headquarter 1	Dock 5th Nixon 6th Howard	7,500	2.43	Howard 6th Market 16th Hospital (NHMH)	21,400	6.93	0.0920	25.03
Headquarter 2	4th Orange	2,000	0.75	Orange 16th Hospital (NHMH)	13,600	4.40	0.0510	13.87
Headquarter 3	Dock 5th Greenfield East Lake Shore	10,800	4.08	East Lake Shore Greenfield 16th Hospital (NHMH)	9,600	3.11	0.01793	4.87

Table 18. Probability of a Rail Crossing Conflict and the Corresponding Expected Delay of Zone 1 for the Rescue Squad from the Secondary Station

Section Description	Station	From Station to Caller: Path	Distance (feet)	Travel Time (minutes)	From Caller to the Nearest Hospital: Path	Distance (feet)	Travel Time (minutes)	Probability of Conflict	Expected Stopped Delay (seconds)
	1	Park Avenue, 17th, Market, 6th, Howard	20,600	6.67	Howard, 6th, Market, 16th, Hospital (NHMH)	21,400	6.93	0.1168	31.77
	2	Park Avenue, 17th, Orange	13,000	4.21	Orange, Market, 16th, Hospital (NHMH)	13,600	4.40	0.0944	25.67
	3	Park Avenue, Dawson, 16th, Greenfield, East Lake Shore	15,200	4.92	East Lake Shore, Greenfield, 16th, Hospital (NHMH)	9,600	3.11	0.01793	4.87

Section #	Center
1	Howard & 7th
2	Orange & Eighth
3	East Lake Shore



Empie

Section #	Area %
1	32.67
2	50.50
3	16.83
	100.00

Table 19. Probability and Expected Stopped Delay Figures of Zone 2 for Primary Rescue Squad Station

Section Description	Station	From Station to Caller: Path	Distance (feet)	Travel Time (minutes)	From Caller to the Nearest Hospital: Path	Distance (feet)	Travel Time (minutes)	Probability of Conflict	Expected Stopped Delay (seconds)
Zone 7: (fire service zones)									
1. North of RR Crossing (Center at Colonial Drive)	Empie	Park Avenue Country Club Colonial Dr.	7,400	2.80	Colonial Dr. Market 16th Hospital (NHMH)	18,000	5.83	0.0102	2.780
2. South of the RR Crossing		NO CONFLICTS			NO CONFLICTS			NO CONFLICTS	
Zone 9:									
1. North of RR Crossing (center located on Stewart Circle)	Empie	Park Avenue E. Forest Hill Mercer Market 30th	11,600	4.38	Stewart Circle 30th Market 16th Hospital (NHMH)	22,800	7.38	0.0298	8.11
2. South of RR Crossing (center located on Kenwood Avenue)		Park Avenue E. Forest Hill Market Kenwood	12,200	3.95	Kenwood Market 16th Hospital (NHMH)	16,400	5.31	0.0152	4.14

Table 20. Probability and Expected Stopped Delay Figures of Zone 2 for the Secondary Rescue Squad Station

Section Description	Station	From Station to Caller			From Caller to the Nearest Hospital				
		Path	Distance (feet)	Travel Time (minutes)	Path	Distance (feet)	Travel Time (minutes)	Probability of Conflict	Expected Stopped Delay (seconds)
Zone 6 Center on Independence Boulevard	Headquarters	Dock 16th Oleander	15,400	5.0	Independence Canterbury Glen Meade Hospital	4,800	1.55	0.00811	2.21
Zone 7 1. South of RR Crossing (Center on Wilshire)	Headquarters	Dock Wrightsville Wilshire	15,600	5.05	Wilshire Wrightsville 16th Hospital	16,000	5.18	0.00610	1.85
2. North of RR Crossing (Center on Colonial)	Headquarters	NO CONFLICTS			NO CONFLICTS				
Zone 8 Center on Greenway	Headquarters	4th Market South Kerr Greenway	21,000	6.80	Greenway South Kerr Park Avenue Independence Hospital	23,400	7.58	0.00833	2.26

Table 19. (continued)

Section Description	Station	From Station to Caller			From Caller to the Nearest Hospital				
		Path	Distance (feet)	Travel Time (minutes)	Path	Distance (feet)	Travel Time (minutes)	Probability of Conflict	Expected Stopped Delay (seconds)
Zone 9									
1. North of RR Crossing (center on Stewart Circle	Headquarters	4th Market 30th Stewart	14,000	4.53	Stewart 30th Market 16th Hospital	22,800	7.38	0.01821	4.95
2. South of RR Crossing (center on Kenwood Avenue	Headquarters	4th Market Kenwood	10,400	3.37	Kenwood Market 16th Hospital	16,400	5.31	0.00923	2.51

next page please

Table 19. (concluded)

Section Description	Station	From Station to Caller			From Caller to the Nearest Hospital				
		Path	Distance (feet)	Travel Time (minutes)	Path	Distance (feet)	Travel Time (minutes)	Proba-bility of Conflict	Expected Stopped Delay (seconds)
Zone 10 Center of the University of North Carolina at Wilmington	Headquarters	4th Market New Center Drive NC 132 College Road UNC Wilmington	32,000	10.36	UNC Wilmington NC 132 Road Wrightsville Avenue Cape Fear Memorial Hospital	16,000	5.18	0.001784	0.485

NOISE IMPACTS

RAILROAD NOISE IMPACTS

The impacts of unit train noise on human activities has been the subject of very little research. Although this section attempts to bring together some major work on train noise, the figures that are cited should be considered as general rather precise indicators of possible impacts.

Based on the general findings of this analysis, the primary effects of disruptive noise levels from passing trains will occur in a corridor extending 1,000 feet from either side of the Belt Line track. Within this corridor, the unit train movement may cause changes in perceived noise levels that are nearly double those under existing conditions.

Methods of Analysis

Since unit trains are not presently being operated on the Belt Line, the range of expected increases in noise levels for various train activities was taken from noise measurements in other communities. The determination of existing noise levels along the Belt was based on similar studies of average community noise levels.

The noise measurement scale used in this analysis is the decible unit (dB) which provides a numerical relationship between relative sound intensities. Since the effect on human hearing is the only concern of this analysis, a modified measurement technique, the dBA scale, is used which identifies sound pressure in terms of human hearing abilities. A third index, the LDN scale is used to designate average noise level conditions for a community during the 24-hour day. As explained in the analysis, LDN values of 50 dBA or greater indicate that community noise levels are at levels disruptive to such human activities as speech and hearing.

Factors Influencing Propagation of Noise from Coal Unit Trains

The noise level from a single coal unit train varies with the track type, size and type of train, and operating conditions. This analysis assumes that the Wilmington Belt Line will be extensively upgraded if unit trains are placed in operation.

Generally, most rail noise is caused by defective train wheels and roar due to wheel-rail roughness. Excessive impact and roughness can increase sound baseline levels by 8-10 dBA, respectively. Since substantial improvements are to be made on

the Belt Line, no correction factors are used in this study for impact or roughness. The presence of curved track also contributes to wheel squeal and howl, which are high and low frequency noises, respectively. For the curve in the Belt Line between Market Street and Covil Avenue, the noise level may increase between 10-20 dBA. It should be noted that these correction factors are not additive but logarithmic. For example, two noise sources each producing 65 dB may generate noise levels together of 68 dB, not 130 dB. Generally, only the largest conversion factor for rail-wheel noise is added to the base level of noise propagation.

Other sources of coal train noise are engine sounds and warning bells and horns. The level of motor noise varies slightly with the type and manufacture of the locomotive, depending on such factors as the exhaust system, engine casing, and cooling fans. Grades also can affect noise levels but are not significant factors in Wilmington. Warning whistles and horns at crossings can produce annoying blasts of around 100 dBA within fifty feet of the tracks.

Terrain and the presence of buildings affect train noise. A hill can reduce noise levels by 10 dBA to 25 dBA. Due to reflection, a large building can cause noise levels from passing trains to increase 3-6 dBA on the side of the building facing the train, while levels behind the building can be reduced by 10-20 dBA. The reduction of noise level within a building depends upon wall construction.

Noise Impacts from Individual Unit Coal Trains

A typical Seaboard Coast Line unit coal train consists of approximately seventy cars of 100-ton capacity and four locomotives. On the Belt Line, upper limit operating speeds are assumed to be 20 miles per hour.

Although a certain amount of work has been performed for use in estimating noise impacts of single train movement, noise contour prediction is not definitive. In an open area, it has been estimated that the peak dBA for a coal unit train pass-by at 100 feet from the track is approximately 85-100 dBA, at 1,000 feet 70-75 dBA, and at 3,000 feet 55-60 dBA. At 1,000 feet, the peak may last only 10-20 seconds, primarily as a function of locomotive noise (EPA, 1977; DOE, 1980). It should be noted that these peak noise levels are for an open area and do not reflect the significant reduction in the noise levels that can be caused by buildings and vegetation. Peak noise levels do not increase significantly with an increase in the number of cars. Although locomotive noise does not vary appreciably with speed, car noise exposure increases both with speed and with the duration of time for passage. Since faster trains tend to have shorter passing

times, the two components of noise tend to compensate each other in terms of predicting total noise exposure.

The passage of individual trains normally disrupts speech communications out-of-doors as a function of distance from the track, loudness of voice, and distance between the speaker and listener. Speech communication within houses and other buildings may also be disrupted, although the potential noise reduction in buildings, can range between 36-63 dBA, not allowing for windows. Normal indoor activities may be disrupted in noise environments above 45 dBA. Thus, it is likely that a train pass-by will probably interfere with normal activities inside residences and buildings near the Belt Line.

A major concern is disruption of speech communication within the schools near the track. Noise levels in classrooms, regardless of train noise, average around 56 dBA. Normal children generally can handle the ordinary background noise of classrooms with no impact on learning, although an increase in background noise of 7 dBA has been shown to reduce learning ability. Children with learning disabilities in communication or hearing show a more severe reduction in comprehension.

Table 21 lists Wilmington schools that would be subject to noticeable sound impacts from passing trains. The walls of the schools likely can be expected to reduce the peak sound level of the train pass-by by approximately 25 dBA, assuming window areas no greater than 50 percent. Schools 1,000 feet or farther from the track likely will receive minimal impact from noise. Schools within 1,000 feet, particularly Blount School, possibly will incur some disruption to speech communication within the classroom.

Multiple Train Movement Noise Impacts

Multiple train movements increase the 24-hour average day-night sound level (LDN). Sounds that occur between 10 P.M. and 7 A.M. are assigned an added weight of 10 dBA in LDN calculations due to the increased annoyance potential of night-time noises. The determination of LDN values for neighborhoods near the track was made by comparing existing train noise effects against the introduction of multiple train movements.

Present train traffic consists of two pass-bys (one round trip) of a freight train along the Belt Line. Assuming baseline LDN levels of less than 50 dBA without the presence of any rail traffic, the present two daily train pass-bys should measure LDN values of 50 dBA at approximately 290 feet from the track,

Table 21. School Impact Data

School	Enrollment	Grades	Age/ Age Additions	Stories	Distance from Belt Line	Wall Construction Material	Principal's Response/Does School Find Present Train Disturbing?	Principal/Res. How many pupils cross tracks to attend school?
Blount	425	K-4	30 yrs.	1	200 feet	Brick/Blocks/ Metal Windows	No	A Few
Forest Hills	400	K-4	52/42/32 yrs.	2	600 feet	Brick/Plaster & Block/Metal and Wood Windows	No	Larger Number
Howe	174	K-4	22 yrs.	1	600 feet	Brick/Blocks/ Metal Windows	No	Majority
Hooper	130	K-12	68 yrs	3	1000 feet	Brick/Plaster/ Wood Windows	No	Serve Entire City
D.C. Virgo	525	7,8,9	18 yrs	2	700 feet	Brick/Block/ Metal Windows	No	A Few
Sunset Park	553	7,8,9	40 yrs.	2	1000 feet	Brick/Plaster/ Block/Metal and Wood Windows	No	Many

increasing to 57 dBA at 100 feet from the track.

The addition of unit trains to Belt Line traffic will change neighborhood noise levels significantly. With an increase of eight trains daily (four round trips), it is estimated that the community LDN value will equal 60 dBA as far away as 1,000 feet from the track and will be as high as 68 dBA at 100 feet from the Belt Line. These values convert to a perceived loudness level that is approximately double that of the existing condition.

For the area along the tracks leading to the proposed private terminal downtown, LDN levels will be 50 dBA at approximately 290 feet from the track and 57 dBA at 100 feet from the track. In the wedge-shaped area where the individual noise contours of the Belt Line overlap the contours of the track leading to the private terminal, the composite LDN levels will be slightly higher than either individual noise contours. It should be noted that the return trips of empty unit trains may be slightly noisier than full unit train trips due to vibration of various metal parts on empty cars that would normally be dampened when full. Also, LDN figures may be overstated due to such factors as attenuation of noise of buildings or understated in a area such as the curve between Covil Avenue and Market Street, the crossings at affected intersections due to warning whistles and horns, and at the two bridge crossings over Burnt Mill Creek. The steel structure with wood ties crossing the Cape Fear River will also generate increased noise but is removed sufficiently from residential areas. In addition, the depicted LDN levels will vary slightly in certain areas due to differences in background LDN levels. The train movement, however, will be a dominant factor in projecting future LDN levels.

The increased LDN noise levels are not expected to cause hearing or other detectable physical damage to residents along the Belt Line. However, the train noise will clearly be disruptive to various daily events, such as conversation, activities requiring mental concentration and sleeping for areas of the city located within 1,000 feet of the Belt Line. Although individual reactions to train noise can be expected to vary significantly, economic research has shown that property values could be negatively effected by noise level increases of the magnitude of unit trains. These and other property costs are investigated in the section of this report on Economic Impacts.

Means of Reducing Noise Levels

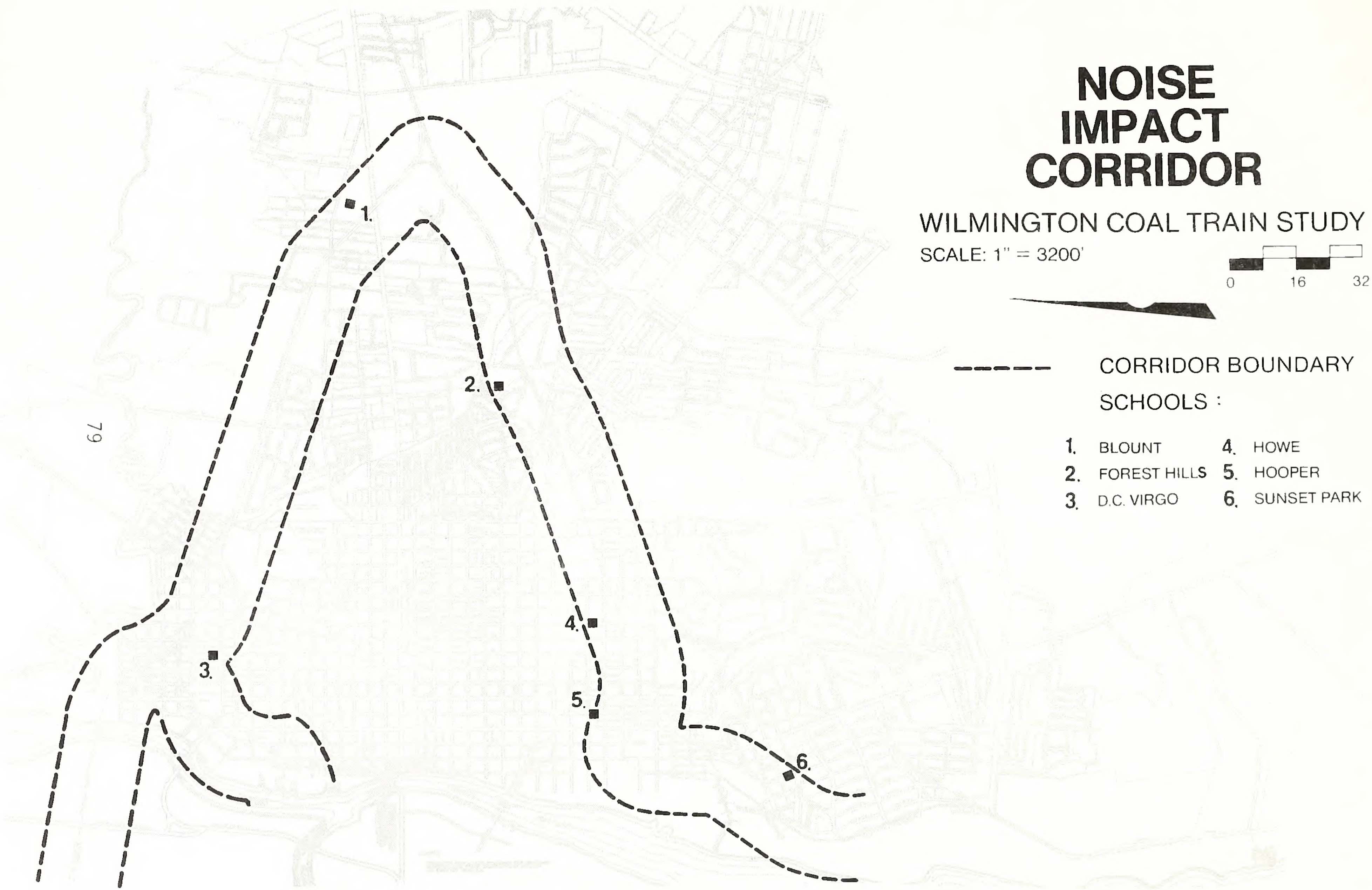
In practice, there are few means to significantly reduce sound levels generated by passing trains. The single most effective

noise reduction measure would be upgrading of the present Belt Line track, preferably to a continuously welded rail. As discussed in the section on the track inspection of the Belt Line, it is absolutely necessary that extensive improvements to be made before any regular movements of unit trains can be accommodated.

Other physical measures include artificial barriers and building retrofitting. Sound barriers along track can reduce noise propagation in residential areas by 10-20 dBA. Types of barriers may range from plantings to fences. Earth berms seem to be the most effective because they both absorb the noise and reflect it up and appear more aesthetic than artificial barriers. However, such berms require much land for installation. Vegetation is largely ineffective for absorbing noises.

In the in-doors environment, building retrofittings, such as door gaskets, double windows, wall insulation and other noise absorbing or buffeting materials can substantially reduce air-borne noise although noises caused from train vibrations are not affected by these improvements. Retrofitting would be a private cost to property owners and may vary substantially from house to house.

The development of a city noise control ordinance would not be enforceable for unit train operations. Section 17 of the Federal Noise Control Act of 1972 provides that stationary and moving locomotives cannot surpass at 30 meters 73 dBA at idle or 90 dBA under maximum load. Rail car noise, which includes wheelrail noise, cannot surpass 88 dBA for trains moving less than 45 miles per hour. The Federal standards represent maximum noise levels for unit trains engaged in interstate commerce.



NOISE IMPACT CORRIDOR
WILMINGTON COAL TRAIN STUDY
SCALE: 1" = 3200'
0
16
32
CORRIDOR BOUNDARY
SCHOOLS :
1. BLOUNT
2. FOREST HILLS
3. D.C. VIRGO
4. HOWE
5. HOOPER
6. SUNSET PARK
1.
2.
3.
4.
5.
6.

MAP 7

VIBRATION IMPACTS

GENERAL VIBRATION IMPACTS

All trains, regardless of length, cargo, speed or track conditions, generate vibrations. While the measurement of train vibrations is neither well understood in theory or application, research is sufficient to enable a general assessment of the magnitude of community effects. Based on the analysis presented in this section, unit train traffic is not expected to cause significant structural damage to residences or other buildings. Vibrations, however, will be perceptible to occupants of structures and may, in some cases, be highly annoying.

Vibrations are generated by forces between the train wheels and rails as a train travels over railroad tracks. These forces are transmitted into ground motions that move away from the tracks in waves similar in manner to the movement of waves across the surface of a pond. About 70 percent of the perceptible vibrations from surface grade railroads result from surface waves (most of which are classified by Rayleigh waves). The remaining subsurface waves enter the ground beneath the track structure. These are shear waves (about 23%) and dilatational waves (about 6%).

It is possible for people to feel rail induced vibrations if they are very near a passing train under certain operating conditions. However, in most cases, humans do not actually feel surface vibrations. Rather, they sense the vibrations as rumbling noises that result from wave action on walls and floors of residences or other buildings. Rail vibrations, thus, intrude on the privacy of a home or other building because construction techniques and materials are sensitive to surface waves. In an out-of-doors environment, humans are sensitive to the train vibration waves only in rare instances.

Measurement Index

As in the case of noise, surface vibrations are measured in terms of decibel (dBA) levels (i.e., the pressure of the waves) and their Hertz frequency (i.e., how many wavelengths occur over a period of time as expressed in the number of cycles per second). A large range of combinations of various decibel levels and Hertz frequencies are within the range of human perceptibility.

Prediction Model

Since coal unit train activity in Wilmington has not yet developed, a prediction model must be based on research reported elsewhere rather than on-site measurement and projection of

vibration effects. Factors peculiar to the Seaboard Belt Line in Wilmington have been taken into account so as to adapt findings in other communities to the local situation.

Rail vibration waves are influenced by such factors as track condition, track construction, equipment running condition, locomotive weight, and soil type. It is likely that numerous other factors contribute to wave characteristics; however, research at this time is extremely limited and largely inconsistent in results beyond the factors mentioned.

The general index of train induced vibrations on at-grade tie and ballast track ranges from 85 dB at 8 Hz to 45 dB at 250 Hz, at 25 feet from the track and at maximum speeds of 60 miles per hour on continuously welded rail. This range is shown in Figure 3. The upper limit can be considered a "worst case" situation in which vibration surface waves can be felt directly as well as heard from the effects on other objects. As the range proceeds to lower levels, the vibration becomes noticeable only to the ear. The wide range of possible decibels and frequencies is simply a function of the thousands of possible mechanical interactions and variations that a passing train can produce on various sections of track.

Two intervening train variables, speed and locomotive weight, can significantly affect the range of vibration levels; however, in the case of Wilmington, they will tend to cancel out each other. Ordinarily, decreased vehicle speed will reduce vibration levels. It is assumed that the average upper limit operating speed of unit trains in Wilmington will be approximately 20 miles per hour. This speed is lower than those in which vibration research has been performed (about 60 mph is the usual measured speed), thus, a reduction amounting to roughly 10 decibels must be factored into the Wilmington model (calculated as $20 \, LOG_{10} V/60$, where V=train and 60=basis of model speed from other community train vibration research). On the other hand, unit train locomotives are somewhat heavier than those reported in vibration research, the measured difference amounting to approximately 10 dB.

It should also be emphasized that vibration increases or reductions in the range of 20 dB over average conditions can result from the general condition of the rail. As mentioned in the Belt Line inspection analysis of this report, the present rail tracks cannot support coal unit trains; thus, it is assumed that the rail would have to be upgraded and would more closely fit the "normal" operating conditions that have been used in rail vibration research. Seaboard Coast Line officials have indicated that continuous welded rail and associated tie and roadbed improvements would be made if unit train activity develops.

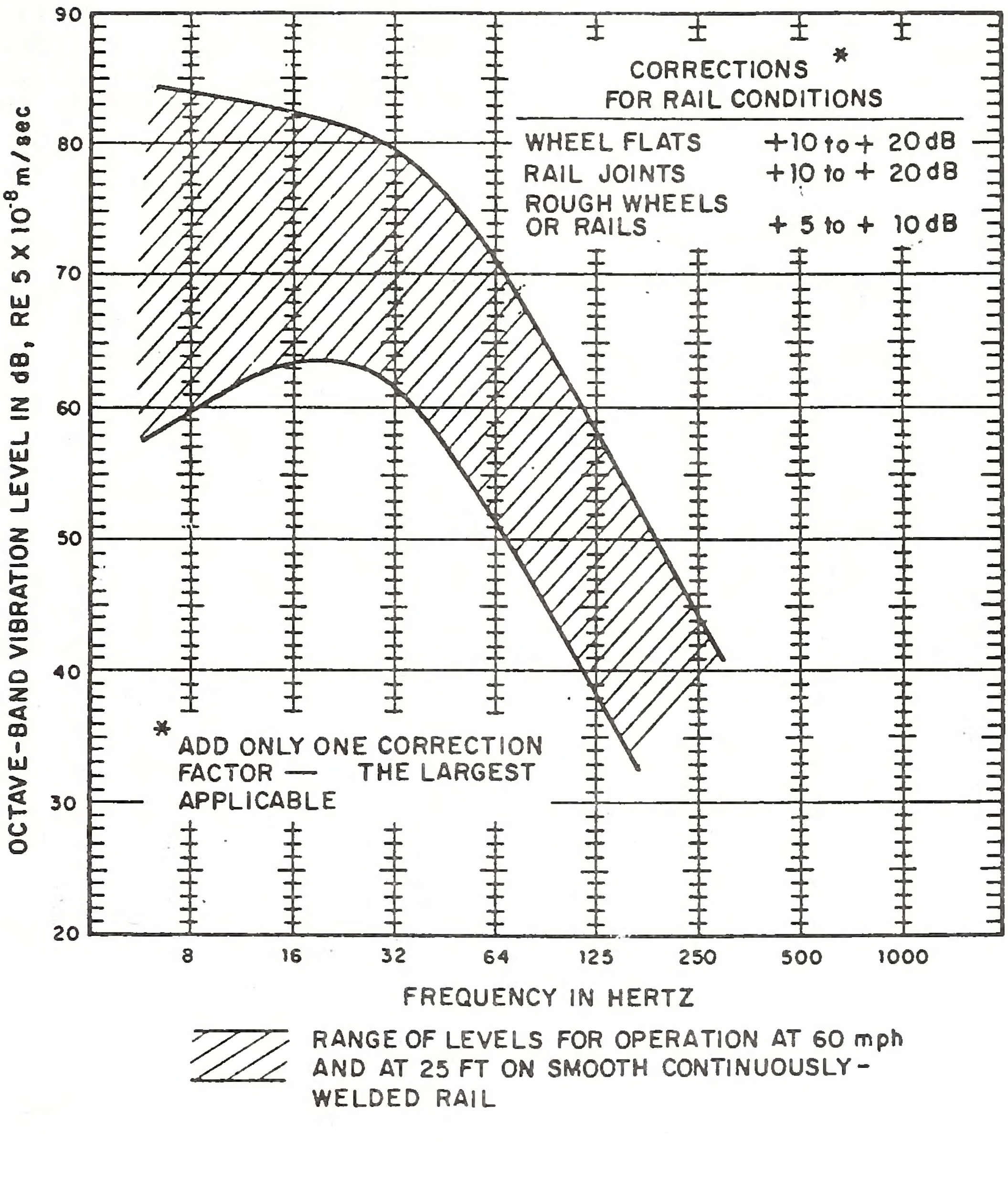


Figure 3. Rail Ground Vibrations 25 feet from At Grade Tie and Ballast Track.

Two very important variables concerning wave strength and energy dissipation should be noted. First, amplitude of surface waves (Rayleigh) drops as a function of surface distance but also due to the nature of the surface and surface objects. Obviously, surface characteristics have substantial variations.

The second variable relates to soil damping properties. There is very little research on this subject, but it is known that the strength of ground waves diminishes least rapidly (i.e., is least absorbed) by soils that are predominately composed of sand, silt, gravel, or loess. Soils under the Belt Line are characterized by these materials.

Effect on City Residents

The general thresholds of perception for feeling vibration or hearing building noise caused by vibrations are shown in Figure 4. As indicated by the figures, the threshold for sensing surface vibrations in the form of rumbling noises ranges from 78 dB at 12 Hz to 35 dB at 175 Hz. The threshold for feeling surface vibrations ranges from 80 dB at 10 Hz to 68 dB at 100 Hz.

Referring to Figure 3 on the range of train vibrations, it can be seen that in a "worst case" situation these vibrations may be felt directly by residents in the city, provided they are in close proximity to the Wilmington Belt Line. However, this threshold limit is just barely reached, and, for more average operating conditions, the vibration impacts will be confined to rumbling produced by surface wave action on buildings.

As a very general rule, it has been estimated that surface vibrations will drop approximately 6 dB with each doubling of distance from the primary twenty-five foot zone of impact at the tracks (as shown in Figure 3). This drop is independent of Hertz frequency.

If this rule is applied to the Belt Line, at the "worst" case vibration impact (85 dB at 8 Hz), the range of decibel levels will decline as follows:

25 feet (from track)	-	85 dB
50 feet (from track)	-	79 dB
100 feet (from track)	-	73 dB
200 feet (from track)	-	67 dB
400 feet (from track)	-	61 dB
800 feet (from track)	-	55 dB

The figures do not account for shear waves and dilatational waves, which decline at approximately 12 dB per doubling of distance from the track source. The impacts of these waves, however, are considered too small as to be measurably significant.

The surface wave figures indicate that the impacts of rail vibrations from the Belt Line will be only in the form of waves that cause rumbling noises in houses and that these will be largely attenuated at distances of 400 to 800 feet from the tracks. An average 600 feet impact corridor is shown on Map 8 .

Mitigation Measures

The only measures that have been successful in significantly reducing rail vibrations involve structural modifications to track structures and on land adjacent to roadbeds. Changes in operating procedures, such as speed or equipment, are less effective but are already taken into account in the calculations made in this section.

In most cases, the rail vibrations will be perceived by residents in the vibration corridor as simply part of the overall noise caused by a passing train. While this may add to the annoyance of living in close proximity to the Belt Line, and will possibly contribute to lowered property values, the vibrations are not expected to be significantly large to require extensive mitigation measures. If exceptions do arise, as for example in houses or other buildings where structural characteristics exaggerate vibration impacts, it may be possible to reduce these effects by the use of ground trenches. The precise design of a trench (i.e., its width and length) must be made on a site basis. Generally, however, the necessary depth will range from 8 to 18 feet in sandy soil. They can be filled with crushed rock but must be protected from the accumulation of water.

Structural modifications to the Belt Line track to reduce vibration would require complete reworking of the roadbed (e.g.

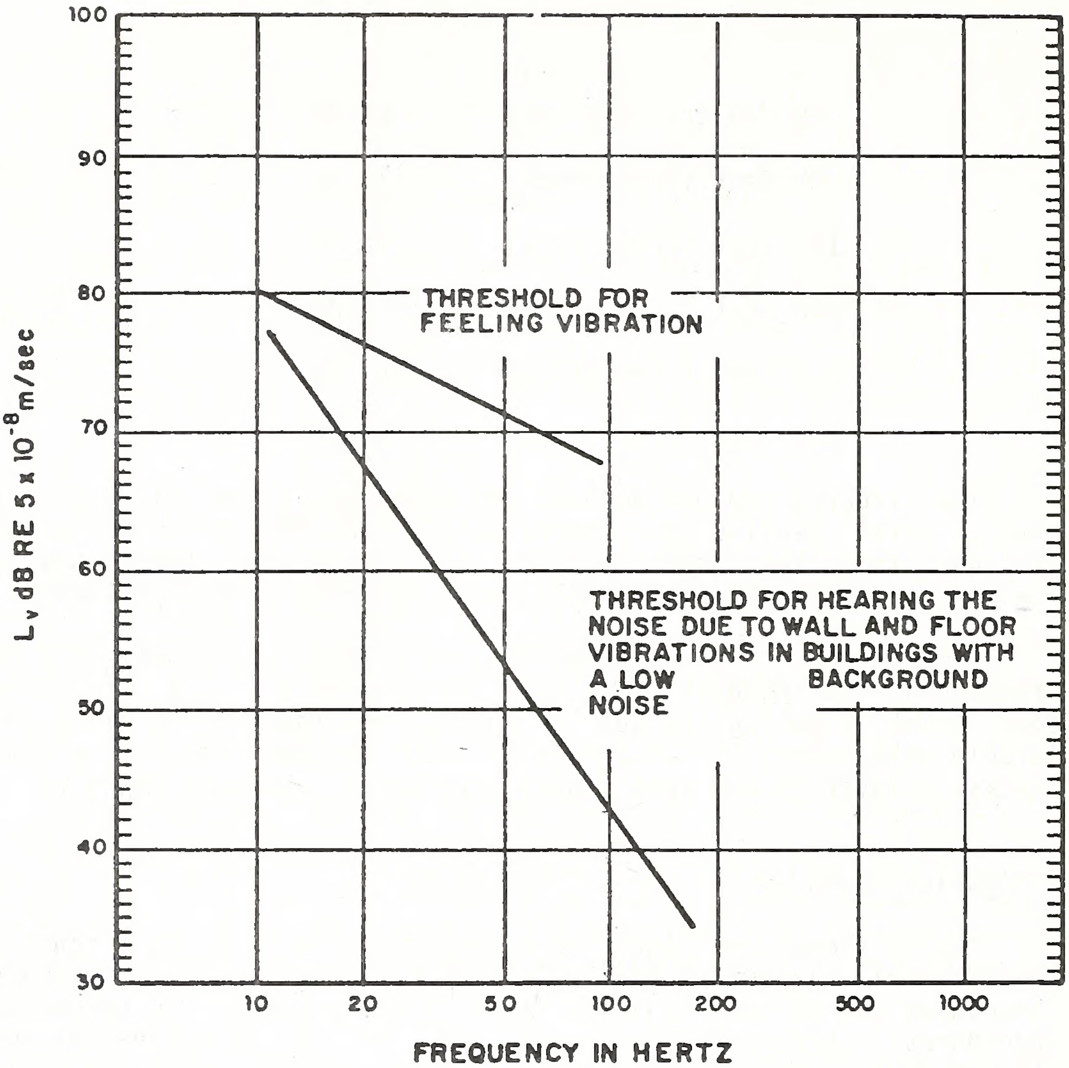
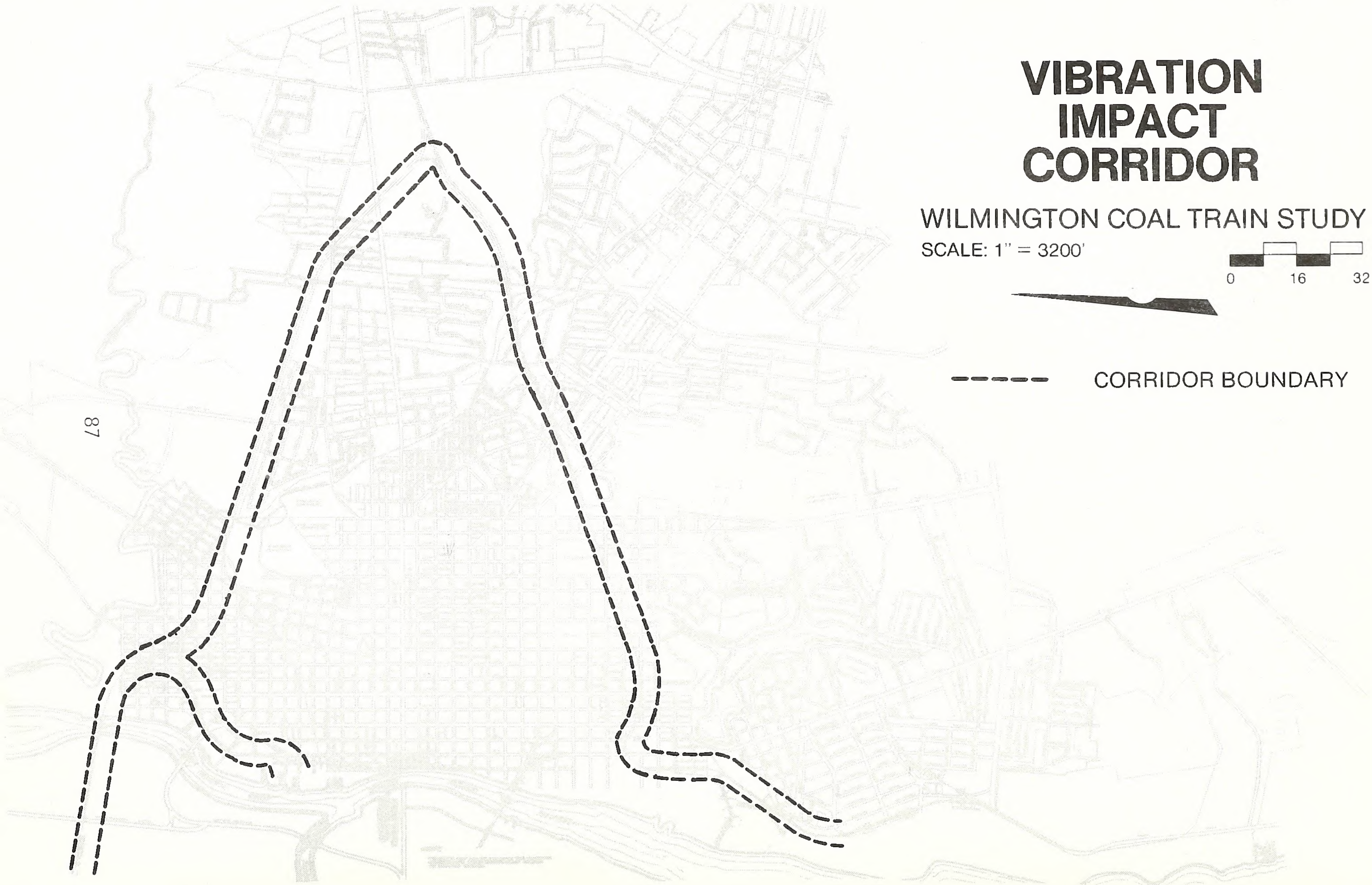


Figure 4. Thresholds of Perception for Vibration and the Resulting Noise in Buildings.

the installation of floating concrete slabs) and is not considered practical given the traffic volume that is projected.


VIBRATION
IMPACT
CORRIDOR
WILMINGTON COAL TRAIN STUDY
SCALE: 1" = 3200'
0
16
32
CORRIDOR BOUNDARY

MAP 8

LOADING AND VIBRATION IMPACTS ON PUBLIC UTILITIES

Vibration and Loading Impacts on Underground Utilities

This section investigates the capability of existing underground water, storm drainage and sewerage pipes to withstand increased train loadings and vibrations on the Belt Line. Eighty-one utilities are crossed by this track. It appears on the basis of the analysis, that loads on 26 of the utilities should be of serious concern. These findings are explained below.

Utilities Investigated

The locations, sizes and depths of the city's underground water, storm drainage and sewerage utilities were provided by the Public Works Department. The general locations of the utilities are shown on Map 9. Records of the Department indicate that 29 of the pipes crossing under the Belt Line are surrounded by steel casings. These pipes should be capable of carrying the increased loads and vibrations.

The remaining 52 underground utilities are not protected by casings. Loading abilities recommended by the American Railway Engineering Association have been calculated for each of these pipes. The results of these analyses are summarized in Table 22.

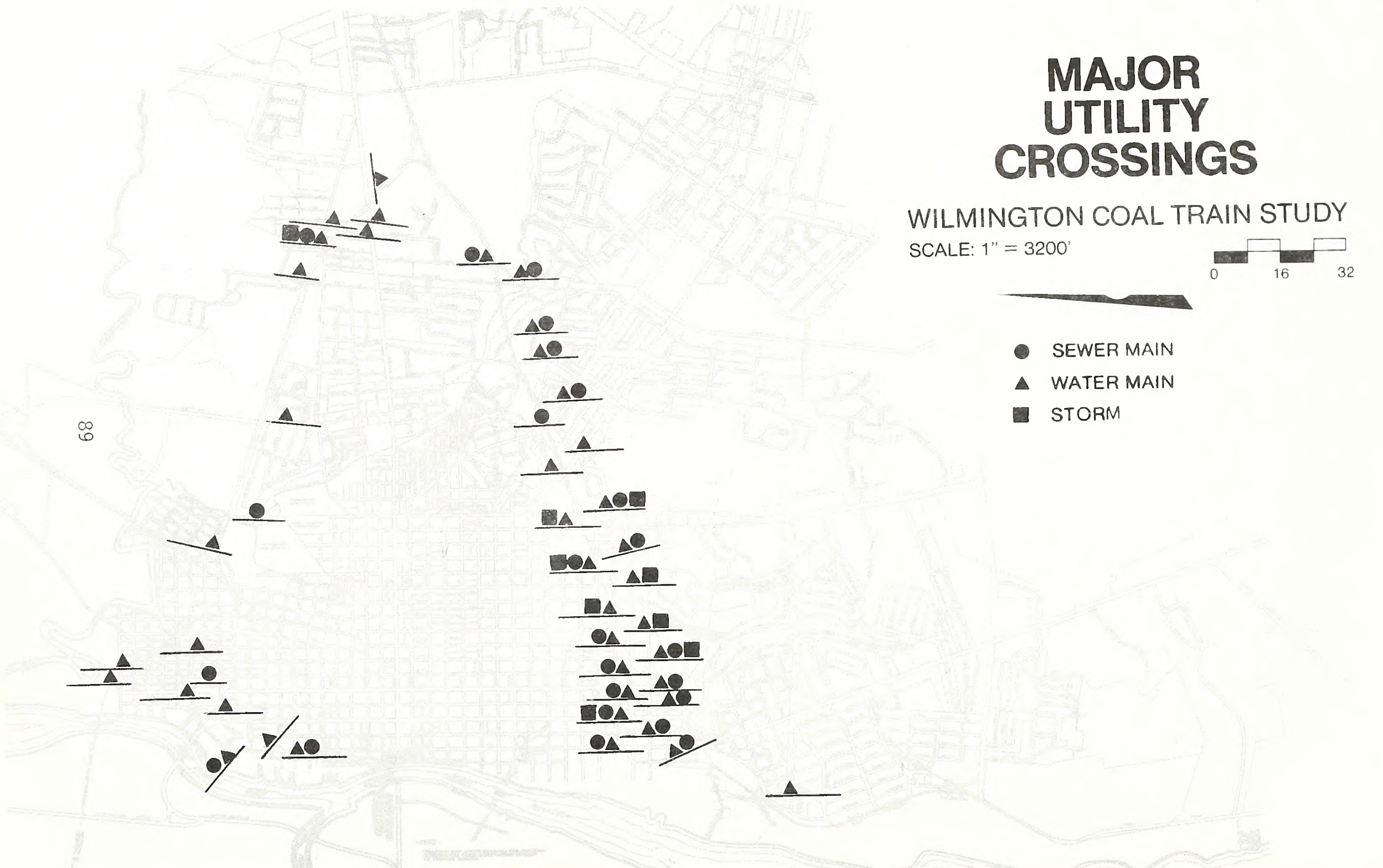
Methods of Analysis

The factors that are entered into determination of loads include the weight of the locomotives, the impact of these engines while in motion, the track structure and the soil types supporting the track through which the underground pipe is located. Recommended loadings are expressed in pounds per linear foot of pipe surfaces. The length of a train and the weight of individual cars are not important since the engine weight represents the heaviest load concentration on an underground pipe.

A number of assumptions about the utilities under the Belt Line are necessary in order to calculate projected loads. These include the following:

1. No significant adhesive qualities are assumed for the soils under the Belt Line. (i.e., it is not assumed that the soils support any of their own weight above underground pipe).

2. It is assumed that the underground pipes were installed by boring or at least are supported in the ground similarly to construction by boring.


MAJOR
UTILITY
CROSSINGS
WILMINGTON COAL TRAIN STUDY
SCALE: 1" = 3200'
0
16
32
SEWER MAIN
WATER MAIN
STORM

MAP 9

Table 22. LOAD ANALYSIS

Facility	Location	Pipe Material	Pipe Depth	Installation Bore	Acceptable Load (lbs.)	Projected Load (lbs.)
8" Sewer Main	8th St.	TCP	3'	14"	2,000	2,701*
8" Water Main	9th St.	CIP	3'	11.96"	10,000	2,243
24" Storm Drain	9th St.	RCP Class IV	6'	30"	3,000	4,530*
6" Water Main	10th St.	CIP	3'	9.48"	11,800	1,778
24" Storm Drain	10th St.	RCP Class IV	4'	30"	3,000	5,445*
12" Water Main	12th St.	CIP	3'	16.46"	8,300	3,087
24" Storm Drain	12th St.	RCP Class IV	7'	30"	3,000	3,823*
8" Water Main	13th St.	CIP	3'	11.96"	10,000	2,243
8" Sewer Main	13th St.	TCP	4'	14"	2,200	2,398*
12" Water Main	Marsteller St.	CIP	4'	16.46	8,300	2,741
8" Sewer Main	Marsteller St.	TCP	5'	14"	2,200	2,044
24" Storm Drain	13th St.	RCP Class IV	4'	30"	3,000	5,445*
15" Storm Drain	16th St.	RCP	7'	24"	3,000	2,873
8" Sewer Main	17th St.	VCP	4'	14"	2,200	2,398*
18" Storm Drain	17th St.	RCP	6'	24"	3,000	3,284*
12" Water Main	Oleander Dr.	CIP	4'	16.36"	8,300	2,741
12" Sewer Main	Wrightsville Ave.	TCP	4'	19"	2,600	3,164*
6" Water Main	Colonial Dr.	CIP	3'	9.48"	11,800	1,778
8" Sewer Main	Colonial Dr.	TCP	4'	14"	2,200	2,398*
6" Water Main	Forest Hills Dr.	CIP	3'	9.48"	11,800	1,778
18" Sewer Main	Forest Hills Dr.	TCP	5'	28"	3,300	4,431*
24" Sewer Main	Forest Hills Dr.	RCP	5'	30"	3,300	4,803*
8" Sewer Main	Mercer Ave.	VCP	4'	14"	3,300	2,398

* Exceeds Acceptable Load

Table 22. LOAD ANALYSIS

Facility	Location	Pipe Material	Pipe Depth	Installation Bore	Acceptable Load (lbs.)	Projected Load (lbs.)
8" Sewer Main	Burnett Blvd.	VCP	5'	14"	2,200	2,044
30" Storm Drain	Polk & Central Blvd.	RCP	6'	37.25"	3,000	5,710*
15" Storm Drain	Polk & Northern Vlvd.	RCP	4'	24"	3,000	4,136*
12" Water Main	Front St.	CIP	2'	13.32"	8,300	2,821
6" Water Main	Martin St.	CIP	2'	9.48"	11,800	2,008
8" Sewer Main	Front St.	TCP	4'	14"	2,200	2,398*
8" Water Main	2nd St.	CIP	4'	11.96"	10,000	1,998
8" Sewer Main	2nd St.	TCP	4'	14"	2,200	2,398*
48" Storm Drain	2nd St.	RCP	8'	58"	3,000	7,577*
54" Storm Drain	2nd St.	RCP	8'	65"	3,000	7,577*
6" Water Main	3rd St.	CIP	3'	9.48"	11,800	1,778
8" Sewer Main	3rd St.	TCP	4'	14"	2,200	2,398*
36" Storm Drain	3rd St.	RCP	5'	45.5"	3,000	7,781*
12" Water Main	4th St.	CIP	2'	16.46"	8,300	3,482
8" Water Main	4th St.	TCP	3'	14"	2,200	2,701*
8" Sewer Main	Martin St.	TCP	3'	14"	2,200	2,701*
6" Water Main	5th Ave.	CIP	3'	9.48"	11,800	1,778
6" Sewer Main	5th Ave.	TCP	3'	10.38"	2,000	1,947
6" Water Main	6th Ave.	TCP	4'	9.48"	11,800	1,579
8" Sewer Main	6th Ave.	TCP	4'	14"	2,200	2,398*
6" Water Main	7th St.	CIP	4'	9.48"	11,800	1,579
8" Sewer Main	7th St.	TCP	4'	14"	2,200	2,398*
18" Storm Drain	7th St.	RCP Class IV	6'	24"	3,000	3,284*

(continued)

* Exceeds Acceptable Load

Table 22. LOAD ANALYSIS

(concluded)

Facility	Location	Pipe Material	Pipe Depth	Installation Bore	Acceptable Load (lbs.)	Projected Load (lbs.)
8" Water Main	Covil Ave.	DIP	3'	11.96"	10,000	2,243
8" Sewer Main	Covil Ave.	VCP	7'	14"	2,200	1,548
12" Sewer Main	Colwell Ave.	TCP	7'	19"	2,600	2,100
8" Sewer Main	Princess Place Drive	CIP	6'	11.96"	10,000	1,537
8" Sewer Main	Brunswick St.	TCP	4'	14"	2,200	2,398*
20" Sewer Force Main	Brunswick St.	DIP	4"	25.39	6,500	4,228

* Exceeds Acceptable Load

3. Unless otherwise specified, the reinforced concrete pipes (RCP) shown in Table 22 are assumed to be Class III design, a common standard for concrete pipe.

4. Equal loading abilities are assumed for cast iron and ductile iron pipes. Cast iron pipe is no longer manufactured but has loading qualities that are similar to ductile iron pipe.

It is emphasized that changes in the assumptions could affect load estimations significantly. Detailed site investigations, such as soil sampling, precise depth studies, and similar analyses may be required to establish precisely the effects of increased train loadings.

Findings

Within the assumptions noted, the addition of unit train loads (i.e., four diesel locomotives per unit train at approximately 82,000 pounds per locomotive) will cause loadings that exceed allowable pressures in 26 of the major utilities that are crossed by the Belt Line. These are designated by asterisks in the Table.

Exceeding allowable loads implies that the pipes noted in Table 22 may develop significant structural cracks. These defects could further lead to complete pipe failures.

The findings raised by this analysis indicate that the utility loadings may represent one of the more significant impacts that the city should consider in evaluating the public costs of coal export facilities at the State Port. As emphasized earlier, detailed site investigations of soils, pipes and installation characteristics will be required to determine precisely how severe loading problems will be if unit trains are placed in service on the Belt Line.

If further analysis confirms the loading problems indicated in this section, a substantial cost would be required to correct the loading deficiencies. To give some measure of this cost, a rough analysis was made to determine replacement values for the 25 underground utility crossings where loading problems are suspected. The following assumptions were made in the analysis:

1. It was assumed all pipes suspected of having loading problems would be replaced.

2. Steel casings would be required for replacement pipe at average costs per linear foot based on $5.00 per inch of diameter. Each pipe location is assumed to require a casing extending on each side of the railroad 25 feet from the center-line.

3. Carrier pipe replacement lengths are assumed to average 80 feet per location. Line replacement costs are estimated to range from $20 (for 8-inch pipe) to $75 (for 54-inch pipe) per linear foot.

4. Each pipe replacement location was assumed to require the installation of four man-holes for connections with existing lines. The construction costs of the man-holes are estimated at $125.00 to $200.00 per vertical foot, depending on diameters and depths. A cost of $200.00 per man-hole is assumed for frame and cover expenses.

Based on the assumptions above, it is estimated that replacement costs for lines that may not be capable of bearing unit train loads could amount to roughly $315,000. This amount does not include engineering design, project inspection, project administration and various other costs.

It may be possible in certain cases to use recently developed reinforcement techniques for existing lines and thus, reduce the cost figures. Still, until more detailed studies are undertaken the potential loading effects of unit trains on underground utilities should be viewed as a significant negative impact.

AIR POLLUTION IMPACTS

UNIT TRAIN AIR POLLUTION IMPACTS

Emissions from coal unit trains include coal dust particulates and gaseous air pollutants, from engine exhaust. Given sizeable unit train movements, potential impacts from particulates can range from respiratory illnesses to aesthetic impacts. The potential for coal dust to cause respiratory stress varies greatly from individual to individual, depending primarily on age and overall health. The major potential aesthetic impact is discoloration of the landscape adjacent to the tracks. Gaseous air pollutant emissions contribute to smog, acid rain, and local pollutant concentrations.

Impacts of Coal Unit Trains in Wilmington

A general method of estimating potential dust has been reported by the U.S Department of Energy in a study of an eastern unit coal train. The study estimated a loss of .25% of coal transported over the 700-mile journey due to dust blowing and handling. Potential coal unit train traffic in Wilmington is projected to range up to approximately 28,000 tons per day on the Belt Line. Using the above loss factor of .25% for a 700-mile trip from the Appalachian coalfields, it can grossly be estimated that as much as one to two pounds of coal dust per mile of track per day along the track to the State Port, and one-half pound of coal dust per mile along the track leading to the private terminal could be deposited daily. Assuming that the dust would settle in accordance with the conventional plume modelling, the impact would decrease with distance from the track. These rates of particulate emission, however, would fall below both EPA primary and secondary particulate standards (40 C.F.R. 50, 1976). The secondary standards include considerations of public health and also consideration of aesthetic impacts and vegetation impacts.

Coal dust in large quantities potentially may damage building surfaces in ways ranging from soiling to sulfide staining and damage due to sulfuric acid. These latter types of damage occur only if the coal is sulphur-bearing and has not been cleaned of sulphur prior to train transport. Permanent damage would most likely occur to old masonry buildings where soft and crumbling brick and sand-lime mortar cannot withstand frequent cleaning of blackened surfaces.

As a practical matter, the potential for coal dust emission and related impacts are probably far less than the estimates made above. First, because of the considerable transport distance from the mine, it is reasonable to assume that the coal will settle well before arriving in Wilmington and most dust will have blown

out in the early stages of the trip. Second, the coal unit train will travel at slow speeds on the Belt Line, which will further reduce the potential for coal dust loss. Third, regional climate studies based on precipitation and temperature for the United States indicate that the Wilmington area has a climate that will minimize emissions.

Gaseous air pollutants from diesel-locomotive operations include sulfur dioxide, nitrous oxides, hydrocarbons, carbon monoxide, and aldehydes. Studies performed concerning the potential emissions and impacts from locomotive emissions indicate that short-term ambient concentrations would not exceed Federal ambient air quality standards. Locomotive emissions for train operating personnel meet Occupational Safety and Health Administration (OSHA) and National Institute of Occupational Safety and Health (NIOSH) standards.

Impact Reduction

Based on the research that is available, the impacts from coal dust in Wilmington are expected to be at such minimal levels that it seems unnecessary to pursue any mitigation measures. Several can be noted, however, that can eliminate practically all emissions. Among these is the use of latex sprays on the dust. These are applied at the mine. These sprays have been shown to be cost-effective because they retard coal freezing as well as reduce coal loss. The unit cars can also be sprayed with water after unloading to reduce emissions on the return trip. Neither of these measures could be required as a City regulatory function since the estimated emissions are not expected to exceed federal air quality standards for interstate commerce. Spraying the cars with water would eliminate practically all dust emissions on return trips after unloading at the State Port; however, this level of dust control seems excessive for the assumed tonnage figures. Residual coal dust in the rail cars after unloading is also not expected to be of any significance. Unloading operations are no longer made from the underside of cars, but involves tilting the car over on its sides and top. Nearly complete removal of coal is accomplished.

NEIGHBORHOOD IMPACTS

Neighborhood Impacts

This section identifies the city population most affected by unit coal train environmental impacts due to residential locations. The Belt Line track passes through a majority of city neighborhoods but negative environmental impacts, mainly from increased noise and vibration, will have primary effects on residences within 1,000 feet of the track. At the least, experiences in other communities indicate that nuisance factors from unit trains may lower property values (see section on Economic Impacts). The neighborhood areas that have residences within 1,000 feet of the Belt Line include Brooklyn, Chestnut, East Wilmington, Forest Hills, Wrightsville Avenue, Oleander, Southside, North Lakeside, Dry Pond, Sunset Park, and South Wilmington.

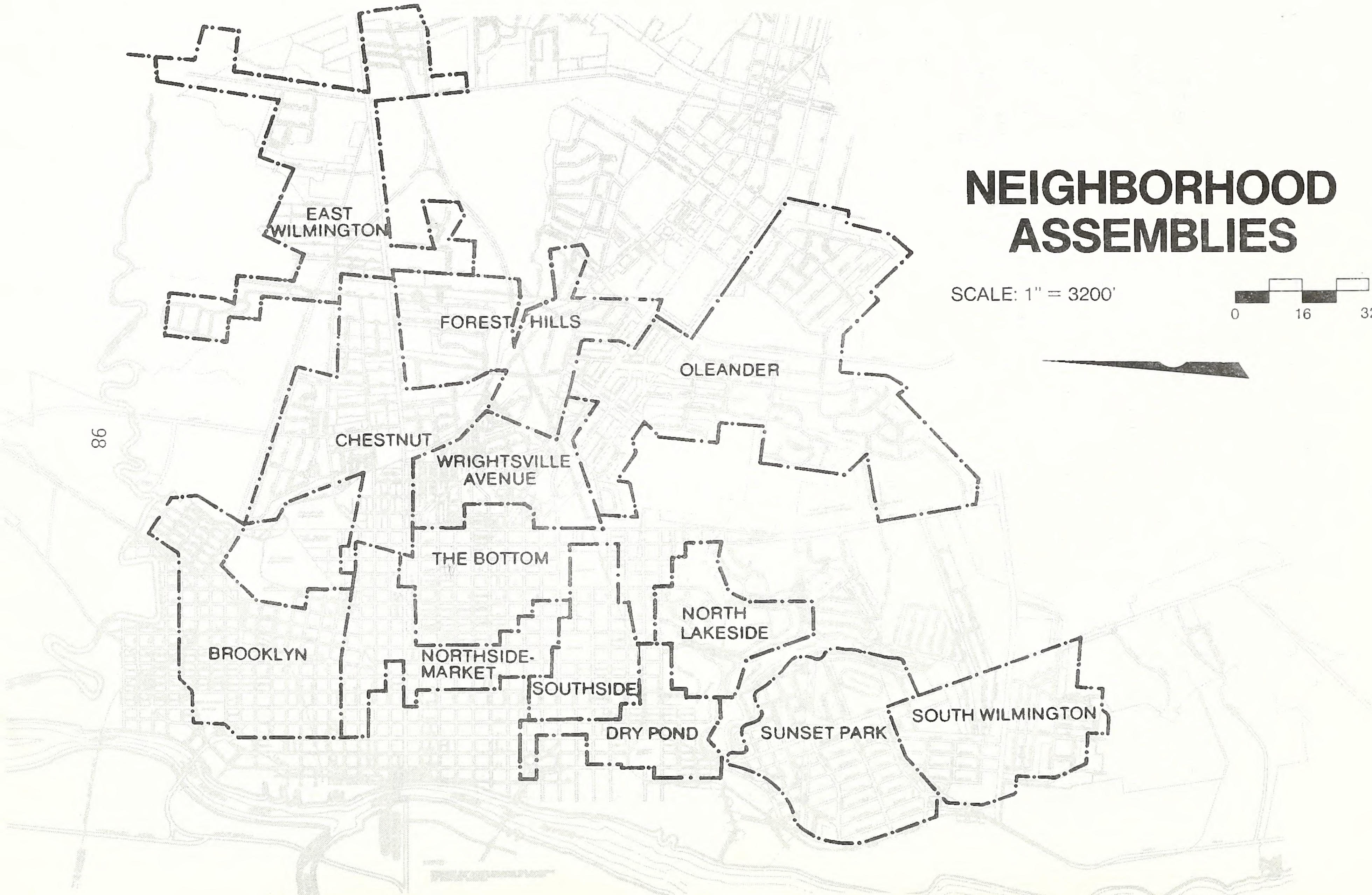
The population figures derived for the various neighborhoods are from 1980 Census block enumerations for neighborhood areas located within 1,000 feet of the Belt Line. Average property values for these neighborhood areas were derived by the Planning Department from city tax assessment records. Potential losses are estimated at $32.00 per $1,000 assessed value (see section on Economic Impacts for explanation of value loss methodology).

The neighborhood summaries indicate that 6,273 persons reside within the primary noise impact corridor as shown below. Of this number 3,121 persons may be subject to further increases in noise due to unit train vibrations. A total of 2,597 residences are occupied by the affected populations. Potential property value losses caused by unit train operations are estimated to total $ 1,045,137, given assumptions noted in the section on Economic Impacts. The grand totals for all neighborhoods are shown below. Individual neighborhood analyses follow.

Impact Summary: All Neighborhood Assemblies

Persons living in 1,000 foot 60 dBA noise corridor:	6,273
Persons living in 600 foot vibration corridor:	3,121
Persons affected by dust pollution:	No Measurable Effect
Housing units in 1,000 foot noise/vibration corridor:	2,579
Estimated property value loss:	$ 1,045,137

NEIGHBORHOOD ASSEMBLIES



MAP 10

Brooklyn Assembly

Neighborhoods in Brooklyn Assembly include Red Cross, Robert Taylor Homes, Brooklyn and Love Grove. Average assessed residential property value is $5,883. Approximately 6,200 feet of Belt Line track is located in the neighborhood assembly. A typical 4,000 foot unit train traveling at 10 miles per hour on the Belt Line will require 11.56 minutes passing time through the assembly (1.92 hours per day per 10 one-way trips).

The Love Grove neighborhood will be particularity affected by unit train operations since the Belt Line crosses the only street (King Street) providing access to this area. Both residences and industries are located in the neighborhood. Although blocking conflicts with emergency vehicles are expected to be very low in typical train operations, access could develop into a serious problem if a derailment ever occurs across King Street.

Impact Summary: Brooklyn Assembly

Persons living in 1,000 foot 60 dBA noise corridor: 211

Persons living in 600 foot vibration corridor: 84

Persons affected by dust pollution: No Measurable Effect

Housing units in 1,000 foot noise/vibration corridor: 103

Estimated property value loss $ 13,947

In addition to the Belt Line, Brooklyn Assembly is crossed in the vicinity of Robert Taylor Homes by a spur line leading to the Nutt Street terminal. Although the Nutt Street terminal site is no longer zoned to allow coal export facilities, the continued presence of track could again lead to coal facility development pressures at some future point in time. For this reason, potential impact figures have been provided in this analysis, but these impacts are not included in the overall summary of neighborhood effects.

Private Terminal (Nutt Street) Branch Line Impacts
Impact Summary: Brooklyn Assembly

Persons living in 1,000 foot 60 dBA noise corridor: 531

Persons living in 600 foot vibration corridor: 252

Persons affected by dust pollution: No Measurable Effect

Housing units in 1,000 foot noise/vibration corridor: 153

Estimated property value loss: $ 20,702

Chestnut Assembly

Neighborhoods in Chestnut Assembly include Arcadia, Belvedere, Brookwood, Carolina Heights and Willowdale. Assessed residential property values average $ 26,555. Chestnut is predominately residential except for a large industrial area north of the Belt Line on 23rd Street. This street also serves as a major access to the New Hanover County Airport. Approximately 5,800 feet of Belt Line track is located in the assembly. Typical train passing time through the assembly is estimated at 11.13 minutes per train or 1.85 hours per day, assuming 10 one-way trips.

Impact Summary: Chestnut Assembly

Persons living in 1,000 foot 60 dBA noise corridor: 772

Persons living in 600 foot vibration corridor: 432

Persons affected by dust pollution: No Measurable Effect

Housing units in 1,000 foot noise/vibration corridor: 308

Estimated property value loss: $ 188,116

East Wilmington Assembly

Neighborhoods in East Wilmington include Barclay Hills, Fairlawn, Greentree Apartments, Maids Park, North Kerr Avenue, and Rosemont Avenue. Assessed residential property values average $ 8,995. Market Street, a major traffic artery, bisects the assembly. This street was identified in the Vehicle Impact analysis to be most severely affected by traffic delays if unit

coal trains are added to the Belt Line.

East Wilmington contains approximately 4,200 feet of Belt Line track. Typical train passing times through the assembly will average 9.31 minutes or 1.55 hours per day assuming 10 one-way trips. Since this section of the Belt Line curves through much of its length, noise levels may be significantly higher due to wheel friction.

Impact Summary: East Wilmington Assembly

Persons living in 1,000 foot 60 dBA noise corridor: 963

Persons living in 600 foot vibration corridor: 207

Persons affected by dust pollution: No Measurable Effect

Housing units in 1,000 foot noise/vibration corridor: 435

Estimated property value loss: $ 90,005

Forest Hills Assembly

Forest Hills Assembly neighborhoods include Beaumont, Camden Circle, Forest Hills, Mercer Avenue and Creek Apartments. Most of the land uses are residential with assessed housing values averaging $ 60,140. Residential streets in Forest Hills carry substantial traffic loads as feeder streets between Market Street and southern portions of the city. Projected unit train traffic delays will increase delay problems significantly.

Approximately 3,150 feet of Belt Line track runs through Forest Hills Assembly. Typical train passing time over this track section will average 8.12 minutes per train or a total of 1.35 hours per day, assuming ten one-way trips.

Impact Summary: Forest Hills Assembly

Persons living in 1,000 foot 60 dBA noise corridor: 593

Persons living in 600 foot vibration corridor: 347

Persons affected by dust pollution: No Measurable Effect

Housing units in 1,000 foot noise/vibration corridor: 232

Estimated property value loss: $ 320,907

Wrightsville Avenue Assembly

Wrightsville Avenue neighborhoods include Carolina Place, Pinehurst, and Spofford Mills. Assessed housing values average $ 20,166. Substantial traffic enters the neighborhood on the major traffic arteries of Wrightsville Avenue and Oleander Drive. A major traffic back-up problem on Dawson Street immediately south of the assembly near 16th Street is expected if unit trains are placed in service on the Belt Line (see section on Vehicle Impacts).

Approximately 4,200 feet of Belt Line track traverses the assembly. Average passing times per unit train are estimated to be 9.31 minutes. For ten one-way trips daily, passing times will total 1.55 hours.

Impact Summary: Wrightsville Avenue Assembly

Persons living in 1,000 foot 60 dBA noise corridor:	149
Persons living in 600 foot vibration corridor:	37
Persons affected by dust pollution:	No Measurable Effect
Housing units in 1,000 foot noise/vibration corridor:	58
Estimated property value loss:	$ 26,901

Oleander Assembly

Oleander Assembly includes the neighborhoods of Country Club, Glen Meade, Highland Hills, Lincoln Forest, Oleander, South Oleander, Chateau Terrace Apartments and Oleander Court Apartments. Primary noise and vibration impacts are confined to the Country Club and Chateau Terrace areas. Assessed housing values average $ 20,166. Traffic delays in Oleander Drive, which bisects the neighborhood, are estimated to double in the vicinity of the Belt Line.

The Belt Line track in Oleander Assembly is approximately 2,100 feet in length. Average passing time per unit train would be 6.93 minutes. Daily pass-by times for ten one-way unit trains will total approximately 1.16 hours.

Impact Summary: Oleander Assembly

Persons living in 1,000 foot 60 dBA noise corridor: 284

Persons living in 600 foot vibration corridor: 146

Persons affected by dust pollution: No Measurable Effect

Housing units in 1,000 foot noise/vibration corridor: 119

Estimated property value loss: $ 55,194

North Lakeside Assembly

North Lakeside Assembly is composed of Lake Forest, Lake Village and Houston Moore neighborhoods. The vast proportion of the assembly land area is occupied by multi-family housing, much of which was constructed for ship-workers in World War II. Assessed property values average $ 11,380.

Approximately 1,200 feet of the Belt Line passes near the northern border of North Lakeside Assembly. Average neighborhood passing times per unit train will be approximately 5.90 minutes. Daily passing times for ten one-way trains will be 1.00 hour.

The Lake Village area of North Lakeside Assembly should be given particular attention in the evaluation of unit train neighborhood impacts. This area contains a large number of vacated frame duplexes that were built during World War II. Attempts to rehabilitate these structures have not been successful, but the neighborhood clearly would benefit if the units could again serve as useful housing. The addition of negative impacts from increased train traffic on the Belt Line may further constrain private developer interest.

Impact Summary: North Lakeside Assembly

Persons living in 1,000 foot 60 dBA noise corridor: 263

Persons living in 600 foot vibration corridor: 58

Persons affected by dust pollution: No Measurable Effect

Housing units in 1,000 foot noise/vibration corridor: 159

Estimated property value loss: $ 41,617

Southside Assembly

Southside Assembly contains the neighborhoods of Hillcrest, Jervay Homes and Southside, each of which have residences within 1,000 feet of the Belt Line tract. Assessed values for the residential units average $ 11,380. Two local traffic arteries, 16th and 13th Streets, carry large traffic volumes through the neighborhoods and will have substantial increases in vehicle delays if unit trains are added to the Belt Line.

Approximately 4,000 feet of the Belt Line is located in Southside Assembly. A unit train will require 9.09 minutes transit through the assembly, totaling 1.51 hours for ten one-way trips.

Impact Summary: Southside Assembly

Persons living in 1,000 foot 60 dBA noise corridor:	979
Persons living in 600 foot vibration corridor:	535
Persons affected by dust pollution:	No Measurable Effect
Housing units in 1,000 foot noise/vibration corridor:	348
Estimated property value loss:	$ 91,086

Dry Pond Assembly

Dry Pond Assembly includes the neighborhoods of Dry Pond, Solomon Towers, Nesbitt Courts, and Greenfield. Property value assessments average $ 11,380. Third, Fifth and Front Streets carry high traffic volumes through the assembly and will experience increased traffic delays and congestion during unit train movements.

Approximately 7,200 feet of the Belt Line track pass through the Dry Pond Assembly. Average passing times through the Assembly per unit are estimated at 12.72 minutes (10 miles per hour speeds). Daily passing times for ten one-way trips will require 2.12 hours. These totals may be considerably higher since the trains will enter the State Port area shortly after passing through the assembly. It can be expected that train noise levels will be higher than usual due to curved track and braking operations as the train proceeds toward the State Port area.

Impact Summary: Dry Pond

Persons living in 1,000 foot 60 dBA noise corridor: 908

Persons living in 600 foot vibration corridor: 638

Persons affected by dust pollution: No Measurable Effect

Housing units in 1,000 foot noise/vibration corridor: 458

Estimated property value loss: $ 119,877

Sunset Park Assembly

Sunset Park, which lies opposite the State Port, includes the neighborhoods of Summer Hill, Summer Hill Apartments, Sunset Park and Woodland. Assessed housing values average $ 14,904. Unit train conflicts with street traffic will not cause traffic back-ups in the assembly but convenient access to or from the downtown and other areas north of Sunset Park will be effectively blocked during train pass-bys.

The Belt Line parallels the western border of Sunset Park Assembly for 6,200 feet as its enters the State Port area (through Optimist Park below Front Street). Trains along this section will be braking for entry to the State Port. Those leaving the State Port for the return trip will, of course, be accelerating. Transit times for unit trains will vary considerably in this area, with movements involving braking operations, start-ups, engine idling, backing up, uncoupling and unloading operations.

Impact Summary: Sunset Park

Persons living in 1,000 foot 60 dBA noise corridor: 443

Persons living in 600 foot vibration corridor: 293

Persons affected by dust pollution: No Measurable Effect

Housing units in 1,000 foot noise/vibration corridor: 156

Estimated property value loss: $ 53,476

South Wilmington Assembly

South Wilmington Assembly includes the neighborhoods of Long Leaf Park, Riverside Apartments, Sunset Hills and South

Wilmington. Primary unit coal train impacts would be confined to Sunset Hills. Assessed property values in the neighborhoods average $ 14,904.

The State Port areas serves as the western border of South Wilmington. At this location, the Belt Line track is on State Port property (rail tracks on this property are owned by the state) and will have no influence on local street traffic. Unit train movements in the State Port area will require approximately 2.5 to 3 hours per train for unloading and turn around operations.

<u>Impact Summary: South Wilmington Assembly</u>

Persons living in 1,000 foot 60 dBA noise corridor:	177
Persons living in 600 foot vibration corridor:	92
Persons affected by dust pollution:	No Measurable Effect
Housing units in 1,000 foot noise/vibration corridor:	68
Estimated property value loss:	$ 23,309

APPENDICES

APPENDIX A

The average total delay is calculated for the high level of forecasted train traffic (5 trains).

5 trains per day = 10 one-way trips/day

16 hours of vehicular traffic daily

average number of trains per hour $= m = \frac{10}{16} = 0.625$

Poisson Probability Distribution:

$$P(X) = \frac{e^{-m}\, m^{X}}{X!}$$

$P(X \geq 1) = 0.4647$ = probability of <u>more than one train</u>* <u>arriving in any given hour</u>.

<u>Scenario 1:</u>

Change in peak-hour delay = + 30595.1 Vehicle-Minutes

Change in off-peak delay = + 2361.2 Vehicle-Minutes

Average Delay/Day

= (30595.1) (2) (0.4647) + (2361.2) (14) (0.4647)

= 43,796 Vehicle-Minutes/day = 730.0 Vehicle Hours/Day

<u>Scenario 2:</u> (follow procedure outlined in Scenario 1 above)

6 trains per day = 12 one-way trips/day $P(X \geq 1) = 0.4723$

Average Delay/Day

= (18365.7) (2) (.4723) + (2495.7) (14) (.4723)

= 32,960 Vehicle-Minutes/Day = 549.34 Vehicle Hours/Day

---

*This probability calculation accounts for cases in which part of one train may still be clearing the Belt Line at the State Port entry while another train is entering the Belt Line east of Hilton Bridge.

Scenario 3: (follows procedure outlined in Scenario 1 above)

Average Delay/Day

= (21,068.4) (2) (.4647) + (1170.1) (14) (.4647)

= 27,192 Vehicle-Minutes/Day

= 453.2 Vehicle-Hours/Day

APPENDIX B

Total Annual number of alarms for Zone 2 = 885

Average daily alarms = 2.42

Area north of railroad crossing = 25.0% of the total Zone 2 area

Average daily alarms from the north section = 0.560

Average hourly alarms from the north section = .0233

Assuming that the calls follow a poisson statistical distribution of:

$$P(X) = \frac{e^{-m}\, m^X}{X!}$$

where:

m = average number of hourly crossings

= (average number of hourly calls) (Number of times the fire engine crosses the semi-closed loop on its way to the destination

$m = .0233 \times 1 = .0233$

Probability of more than one call per hour = P (X 1)

$= 1 - P(x = 0) = 1 - e^{-.0233} = .02330$

There are 10 train round trips per day.

$$m = \frac{10}{24} = .4166$$

Probability of one or more trains per hour occupying the crossing*

$= 1 - e^{-.4166} = 0.3407 = P_2.$

---

* It is assumed though that no more than one train will occupy the semi-closed loop in any given hour.

The probability of more than one fire engine approaching the crossing while a train is already there = $(P_1)(P_2)$ = .00783

For a 4000 train travelling at 10 mph, the average crossing time = 272 seconds.

The expected delay per engine = (272) (.00783) = 2.13 seconds (see Zone 2, page 64).

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GLOSSARY

GLOSSARY

Collier: A ship that is used to transport coal.

Casing: A cylindrical steel pipe which surrounds and protects a carrier pipe placed in its interior.

Decible: A unit for expressing the relative intensities of sounds on a scale from zero, for the average least perceptible sound, to about 130, for the average pain level.

Frog: A railroad track switching device that allows a train to be directed from one track section to another or to cross an intersecting track.

Multiplier: In economics, a number which expresses an economic relationship as a mathematical function.

Pipe Boring: A lengthwise cylindrical cavity made by a rotary excavating machine.

Plume Modelling: A technique used to predict the dispersion of particulates when released into the atmosphere.

Queue: In street traffic, a line of cars that forms when a delay in movement occurs.

Rail Head: The upper part of the railroad track which forms the running surface for the train wheels.

Track Class: A precise designation of railroad track design and condition which is used to specify operation procedures for train movements, including maximum allowable speeds. The lower the track class is, the lower is the maximum operating speed.

Track Gage: A measure of the distance between the left and right tracks which support a train.

Track Joint: The location at which two sections of railroad track are joined.

Unit Train: A train in which cars are all the same types and dimensions and are restricted to transporting a single commodity.

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